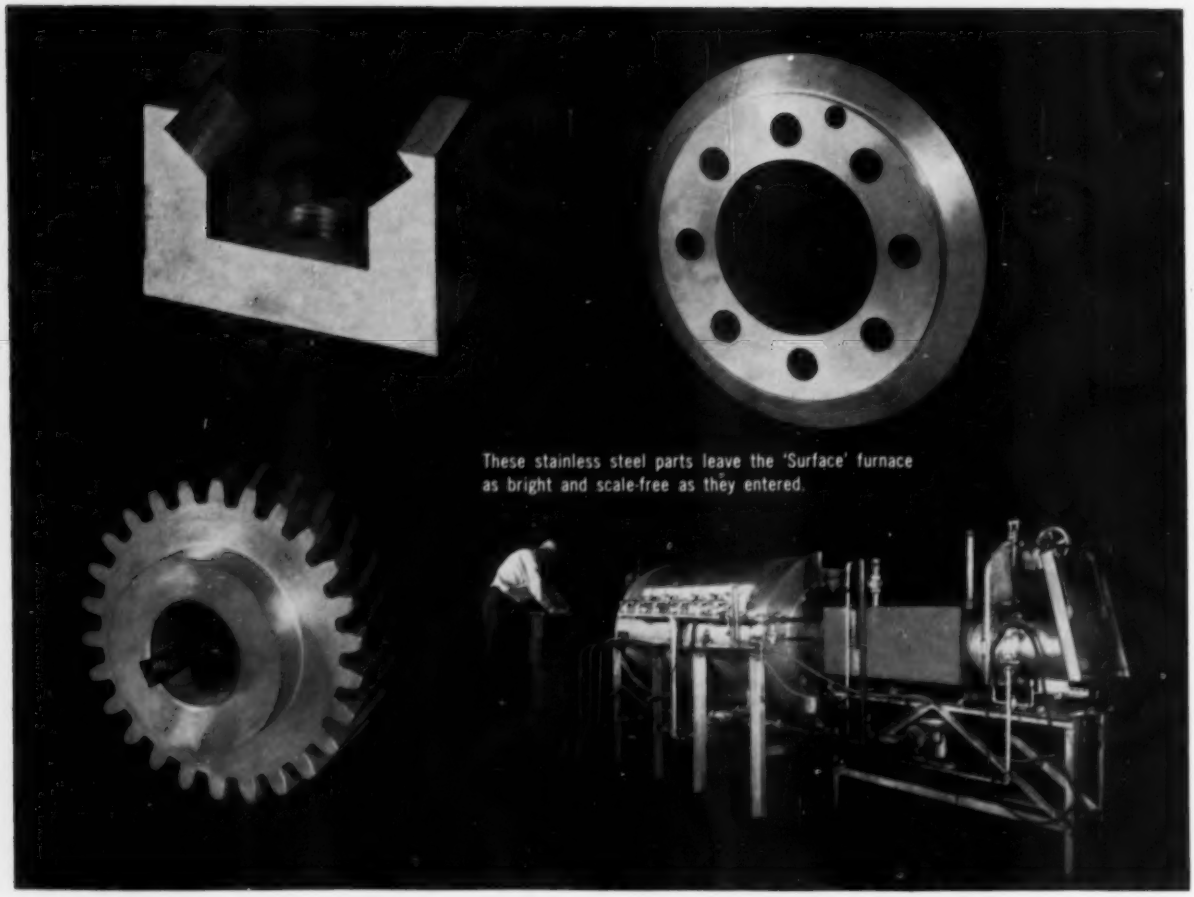
METAL PROGRESS



bright hardened stainless sells!

you can really sell bright hardened stainless and other high alloy steels, because they save money for your customers.

this has been demonstrated by the people at Syracuse Heat Treat Co., Syracuse, N. Y. In the two years since they installed this 'Surface' high temperature muffle furnace, they have sold their customers savings—cost cut $1.87 on one part . . . hand stoning operation cut from 30 to 5 minutes on another . . . delivery in half the previous time . . . tighter specifications met.

and you earn yourself, as the Syracuse people found out, because the furnace delivers parts clean and bright, and eliminates costly, time-consuming descaling operations. The market is good for the premium product this furnace permits. Why not tap it now?

write for the story on bright hardening stainless

Surface
HEAT TREATING EQUIPMENT

SURFACE COMBUSTION CORPORATION, TOLEDO 1, OHIO

Metal Progress

Volume 69, No. 3
March . . . 1956

Prizewinning Cover From Cleveland Art School Competition Is by JACK JOHNSON

Powder Metallurgy Permits Air Cooling of Turbine Blades, by R. W. A. Buswell, I. Jenkins and E. R. Perry 53

A practical solution to operating engines with gas at over 2000° F. has been developed in Britain. Matrices of many tiny cooling passages are formed in metallic blades by volatile cores properly placed in powder metal pressings. (H general, T 25, SG-h, Co)

Selection and Application of Furnace Atmospheres for Carbon Control, O. E. Cullen 57

A furnace atmosphere containing about 20% CO, 40% H_2 and 40% N_2 can be used to carburize, carbo-nitride, recarburize decarburized surfaces, clean harden or increase the carbon content of strip to a uniform higher level. Careful measurement and control of dew point is needed. (J 2)

Manufacture of Spot Welded Automobile Wheels, by Milton H. Grams 63

Replacing of riveting lines by four-gun spot welding machines relieved a bottleneck in the production of automobile wheels. The welded wheels are stronger and can be assembled automatically with greater control of quality. (K 3)

Production Control of Salt Baths in Germany, by Otto Schaaber 67

Potential of bath is measured by immersing mild steel foil long enough to carburize throughout and estimating its carbon content; quenching power of martempering bath is measured by time needed to heat a small cylinder through a specified range. (J 2)

How Statistical Techniques Solve Metalworking Problems – Part II, by Chester R. Smith 76

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Reduction of Uranium With Magnesium, by H. A. Wilhelm 81

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**The coding symbols refer to the ASM-SLA Metallurgical Literature Classification.*

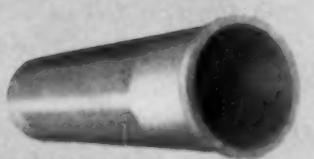
Thermalloy*retorts stay on the job longer...

A large ball and roller bearing company found retort service life increased 30% after they installed Thermalloy retorts. The retorts were used to heat-treat ball-thrust bearing races at an average temperature of 1750°F. for five continuous hours. The specially designed octagonal shape also provided more uniform tumbling action with less marring of parts.

In our Elyria foundry, the most modern facilities are available to turn out quality high-alloy castings. In addition, retorts and muffles are X-ray inspected and pressure tested before shipment to make sure your Thermalloy castings give longer hours of trouble-free service.

For further information on Thermalloy retorts, write for Bulletin T-239. Electro-Alloys Division, 7002 Taylor St., Elyria, Ohio.

*Reg. U. S. Pat. Off.



Thermalloy octagonal retort

Thermalloy pit-type retort

Thermalloy shaker hearth muffle

AMERICAN Brake Shoe COMPANY

ELECTRO-ALLOYS DIVISION
Elyria, Ohio

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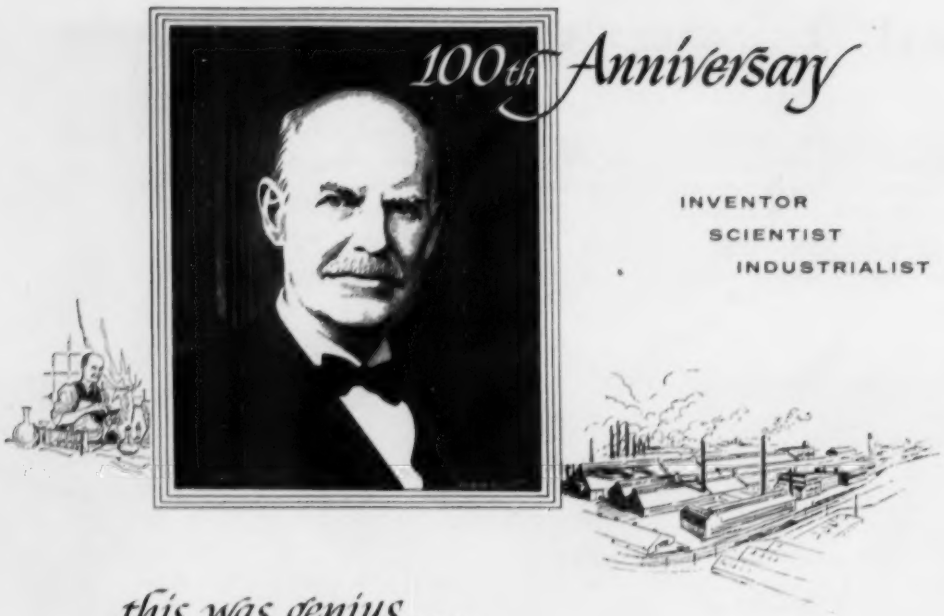

100th Anniversary

INVENTOR
SCIENTIST
INDUSTRIALIST

this was genius . . .

EDWARD GOODRICH ACHESON

Yes, this was genius.

Thomas A. Edison knew it. In paying tribute upon the occasion of Doctor Acheson's passing, he said "... as a former associate I know the world loses a great genius."

Leo Hendrik Baekeland knew it. He remembered him "as a man who combined a most fertile brain with great strength of conviction."

Walter B. Pitkin knew it. This famous psychologist said "As he created his place in our civilization so does that place pass with him. None shall fill it."

And the press knew it. They used in their editorials such phrases as "world's acclaim of a genius," "one of the geniuses of his time," and "the loss of an inventive genius."

But what makes genius?

Employing a mixture of carbon, sand, salt, and sawdust in a simple but effective electric furnace, made up of a few strands of wire, a carbon rod, and a plumber's bowl, Edward Goodrich Acheson was able to bring into being a mass of scintillating crystals rivaling many gems in splendor and almost matching the diamond in hardness. These highly abrasive crystals he crushed and made into grinding wheels, and these wheels, in turn, were used to shape metals and make machines. Called "Carborundum" by Acheson and silicon carbide by the chemist, this new material did its job so well that it is credited with making possible today the mass production of automobiles, tractors, and countless other mechanisms.

Possibly silicon carbide could be made better—harder or sharper. To this end Acheson subjected silicon carbide to higher temperatures for longer periods; what he obtained was not a harder substance but, instead, one of the softest—pure graphite. The extreme conditions to which he had exposed his jewels of industry brought about their disintegration, the silicon passing off as vapor and the carbon remaining as a soft, unctuous residue. Manufactured graphite, destined to be of far-reaching importance, became another of Acheson's contributions to industry.

Unquenchable curiosity, coupled with the indomitable spirit that was his, led him to uncover means of preparing this new product of the electric furnace in the form of plates and cylinders. Put to work as electrodes, these soon revolutionized electrochemical and electrometallurgical operations. Acheson had now made commercially feasible the production of new families of chemicals and laid the groundwork for the present efficient manufacture of steel and alloys.

During Acheson's painstaking efforts to produce graphite crucibles he experimented with many clays for use as binding agents—and he learned much about them—so much in fact that he was able to explain why the ancient Egyptians used straw in their brick making and what caused the formation of the deltas of the Nile and Mississippi. Most important, he discovered a method of rendering graphite colloidal.

Colloidal graphite in modern industry plays a role that is varied and complex, its unique properties finding utility in such dissimilar fields as lubrication, electronics, metalworking, and lithography, to name a few. The techniques originated by Acheson for colloidally dispersing graphite are being applied to other solids including carbon blacks, pigments, and minerals.

To those of us in the companies identified with Doctor Acheson, his perseverance and achievement are an inspiration. We are proud to offer this tribute to his genius on the 100th anniversary of his birth.

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LONDON, ENGLAND

As I was saying...

"HOWDY, PARDNER! Many thanks for this-here cowboy hat! I sure don't deserve it. I rasseled this herd as your president for one year only, and while my head size did increase a mite you made allowances for it when you selected this Las Vegas Rex Bell Cover." And I was pleased at the kind words Elmo Ellsworth (see above left) recited when he told me I had been elected chairman of the board for the coming year of the American Convention and Travel Institute.

We were assembled at Hotel del Coronado, near San Diego, for the annual meeting of the Institute, and had just completed a very interesting and informative three-day session. It really was a pleasure to head up that grand bunch of members—and besides, I received a world of good advice. The words of wisdom I remember best were from my good friend Elmo, who said, "Always buy the first round because the party never will get any smaller."

A.S.M. President Ad Schaefer will soon join me in Palm Springs, and we'll set out on a visit to the Western Chapters. We understand (hearsay) that Edmonton has had a very severe winter, that it has been as cold as 50 degrees below zero, and not above freezing since Thanksgiving. Now I bet you are saying "Bur-r-r, I bet President Ad and Secretary Bill get cold feet and skip Edmonton and Calgary (Alberta) Chapters."

You're on—and you lose. Ad and I are going to hotfoot it direct from Palm Springs to Edmonton and Calgary and make personal appearances and deliver charters to the two youngest Chapters in the A.S.M.

Then we ride the Scenic Dome across Canada to Vancouver to counsel and talk with and before the British Columbia Chapter. Then will follow in order the other Northwest Chapters—Puget Sound (Seattle), Inland Empire (Spokane), Columbia Basin (Richland) and Oregon Chapter (Portland). President Ad will deliver his address and I'll talk on "The A.S.M. of Today and Tomorrow," and perhaps tell a story or a few, and by the end of the trip (it isn't over yet) perhaps I'll be giving Ad's lecture and he'll be telling my stories.

The Shasta Daylight speeds us from Portland to the Golden Gate for rest over the weekend and a session with the executive committee at noon and a meeting in the evening. Then Los Angeles and San Diego in quick order, and we retire to Palm Springs for a long weekend. But soon we will get on our horses again or hitch-hike to Santa Fe to be with the Albuquerque and Los Alamos Chapters for a Ladies' Night to be held in Santa Fe. (My stories go out the window!)

Then to Dallas for the North Texas Chapter get-together before heading for Houston, the seaport on the Gulf of Mexico. Two days in Houston, and over-night to New Orleans for the final meeting of the journey.

At that point President Ad is 24 hours from Philadelphia and I am 32 hours from Cleveland. We will get home and realize it was some jaunt, but it will be well worth it—for where and when in so short a time could you possibly meet and enjoy such a bunch of fine fellows as in the A.S.M. That pleasure alone is worth traveling thousands, yes, many times a thousand miles, to enjoy.

Cordially,

Bill

W. H. EISENMAN, *Secretary*
AMERICAN SOCIETY FOR METALS

FOR SALE: Slightly used arctic equipment: two pairs felt boots; two wool union suits, heavy, ankle-length, red; two raccoon coats (college style) with pull-down caps; two sets electrically heated ear muffs plus two sets batteries with carrying case. No offers expected—no offers rejected.

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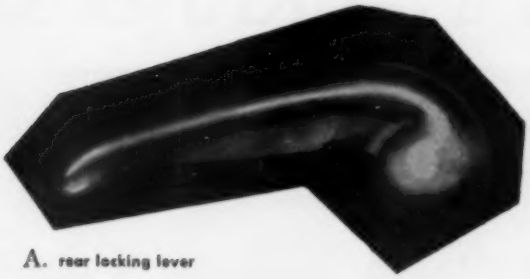
give THUNDERBIRD tops a snug fit the year around

The Motor States Products Division of Detroit Harvester Co.—a major supplier of top assemblies for convertibles—has found Mueller Brass Co. forgings an ideal answer for securely fastening down the tops on the Ford Thunderbird. In a summer shower or in the snow of winter the top is always snug and draft-free. There are a pair of each of the three Mueller Brass Co. forgings shown here used in locking the Thunderbird top securely around the sides and rear deck. The locking lever (A) is incorporated in the top and operates a locking pin that fastens into the rear hold down clamp (B). A pair of side hold down clamps (C) are located just behind each door opening and clamp fasteners on the top hook into these forgings to rigidly hold the top in position. These forgings hold the necessary close tolerances and provide an excellent surface for buffing and chrome plating. In addition, the price is favorable and deliveries are good. For these reasons, as well as their inherent strength and durability, a switch to Mueller Brass Co. forgings can prove advantageous. Write today for our engineering manual (No. H-58565) . . . or better yet, call in one of our engineers to investigate possible forging applications in your products.



A. rear locking lever

B. rear hold down clamp

C. side hold down clamp

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Mueller Brass Co. Forgings Engineering Manual H-58565 ☐

Tuf Stuf Aluminum Bronze Alloys Engineering Manual H-58563 ☐

600 Series Bearing Alloys Engineering Manual FM-3000 ☐

Copper Base Alloys in Rod Form Engineering Manual FM-3010 ☐

METALS AND ALLOYS REVIEW

by FRANK M. LEVY, Director of Research

The other day one of our sales engineers stopped in to discuss gear applications and the subject got around to the amount of zinc permissable in gear and bearing alloys. Engineering books state that zinc is not desirable in bearing alloys. While this statement is true as regarding the commonly used copper-tin and copper-tin-lead alloys, it does not necessarily apply to other types of alloys. The 600 series bearing alloys, in which I am keenly interested, depend upon a high zinc content along with several other metal constituents to provide them with their fine bearing properties.

My explanation to our sales engineer was somewhat as follows: The question as to whether or not zinc is detrimental in a bearing alloy depends upon the remaining constituents in the alloy. A comparatively small amount of zinc is detrimental in a phosphor bronze alloy containing 80% copper, 10% tin and 10% lead. A zinc content of 4% is permissible in a bearing alloy containing 88% copper, 4% tin and 4% lead when used in an application not subject to heavy loads. In these alloys the tin combines with some of the copper to form a hard copper-tin constituent which is distributed through the soft copper matrix, or mat of copper. The higher the percentage of tin present, the greater the quantity of hard copper-tin constituent formed. Zinc also combines with copper increasing the hardness of the matrix. Therefore, when zinc is present along with a high tin content, the matrix becomes too hard and is "out of balance" resulting in poorer bearing qualities.

In the 600 series, copper, silicon, manganese, etc., are present with zinc. There is sufficient manganese present to combine with the silicon to form a purple manganese silicide which is embedded in the copper-zinc matrix. *Since the manganese-silicide constituent has a much higher micro hardness than the copper-tin constituent in phosphor bronze, the matrix of the 600 series alloys can have a higher hardness without impairing the bearing properties. In this instance, zinc is not detrimental but desirable because it produces an alloy with a high Brinell hardness which resists pounding and distortion.*

Like many engineers, we, too, were skeptical of the bearing properties of the first 600 alloy developed. A manufacturer of worm driven truck transmissions was having difficulty with the failure of chill cast high tin bronze gears in busses used in the hilly section of Los Angeles and Pittsburgh, and solved his problem by using gears made from 600 metal.

Since that time, we have had over a hundred successful applications on difficult bearing problems where cast bearing bronzes have failed. An interesting observation is that once a customer uses 600 alloys, he not only finds other applications, but continues to use it over a long period of years. Our original customers are still on our books.

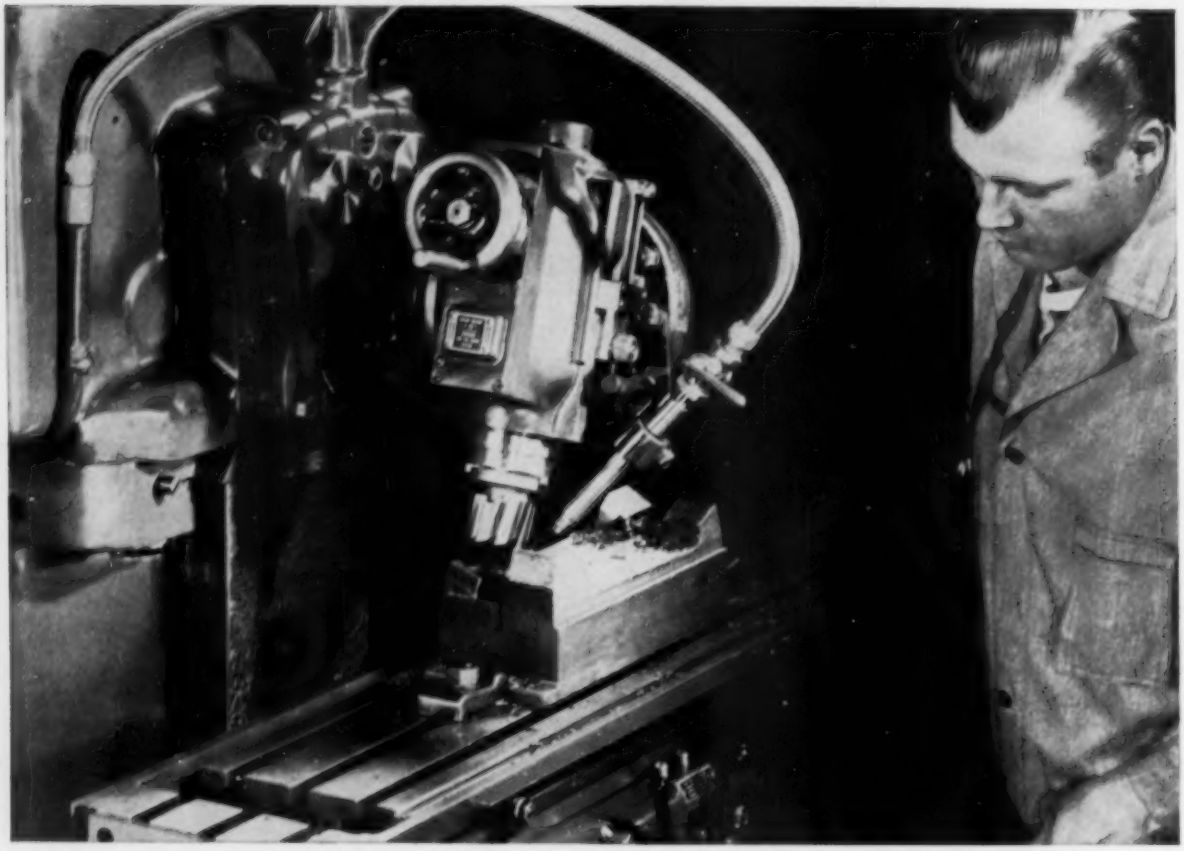
In conclusion, we agree that zinc is detrimental to the bearing properties of the phosphor bronze type of alloys, but is of benefit to the 600 series alloys, *as it makes a harder matrix*, permitting the alloy to resist pounding action better than the softer phosphor bronze alloys.

I've just about run out of space for this time but we'll have another subject for discussion later. If you have any problems or questions about non-ferrous alloys, just write me here at Mueller Brass Co. and we'll see what we can do.

MUELLER BRASS CO.

PORT HURON 20, MICHIGAN

170



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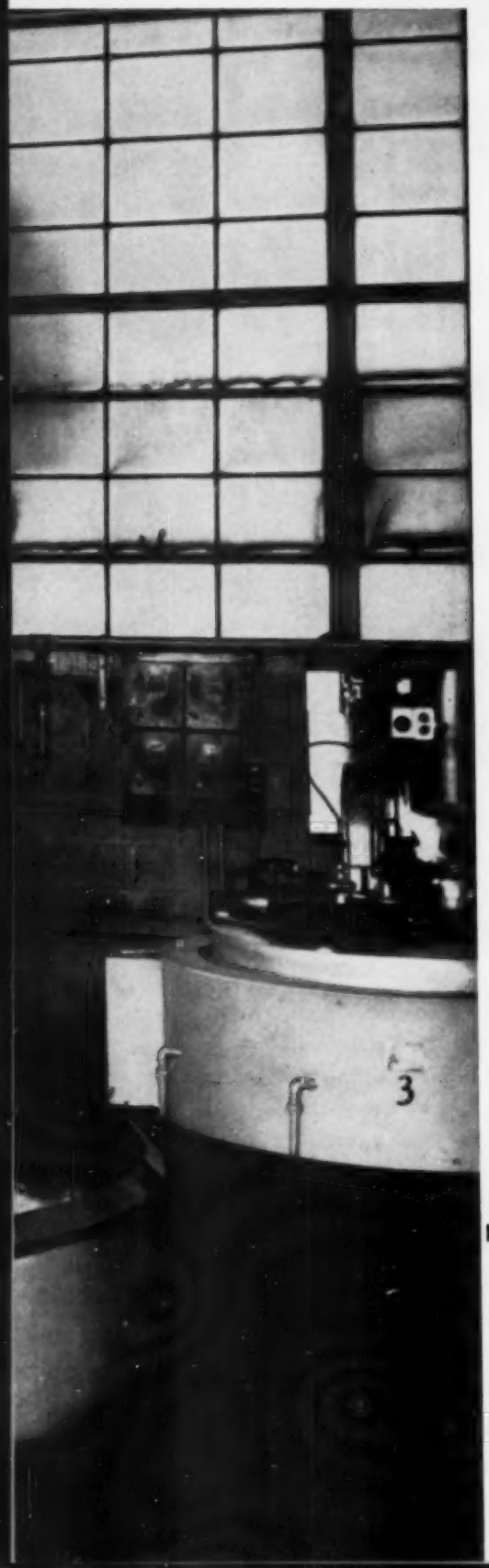
"PARK AAA GIVES US FAST

Inspecting the dramatic action of Park Chemical's AAA quench oil are (l. to r.): Harold F. Wagner, Service Metallurgist, Commercial Steel Treating Corp.; Wm. Askew, from Park's Detroit office; Anthony J. Beck, Chief Engineer, Commercial Steel Treating Co.; and Merle Hoensheid, Plant Manager, Commercial Steel Treating Corp.

QUENCHING WITH LOW DISTORTION"



Says Merle Hoensheid

General Manager, Stephenson Highway Plant
Commercial Steel Treating Corp., Detroit, Michigan

"As Detroit's largest heat treaters, and one of the oldest commercial heat treaters in the country, Commercial's customer list reads like the blue book of industry. For the automotive leaders, for example, our heat treating must be of the highest quality. We can't afford to take chances on any of our heat treating equipment or supplies.

"That is why we have standardized on so many of Park Chemical Company's products. Park's AAA quench oil is a typical illustration of the dependability we find in their products.

"We regard the 7,600-gallon quench oil operation in our new Plant No. 2 as a vital cog in our overall heat treat production. Elaborate cooling chambers maintain a quench oil temperature of approximately 140 deg. F. After carburizing, the heat treat load is lowered by air control into the quench, as you see it here.

"Park's AAA quench oil has been used here for fourteen months. It has extremely long life, with no breakdown, saponification, or rancidity. It has given us faster quenching, higher and more uniform hardness, with little or no distortion, warping, or cracking. Rejects are rare.

"Despite the exacting demands of outstanding customer requirements involving many types of steels, we have learned to depend on the more than satisfactory results from Park's AAA quenching oil."

Park Triple A Oil is a blend of specially refined mineral oils containing accelerators and special anti-oxidants. It cools steel faster in the critical temperature ranges and provides slow and uniform heat removal in the lower temperature ranges. Thus, the best surface hardness and penetration are achieved with no danger of cracking or distortion. It also has longer life and bright quenching properties. Park Triple A Oil is especially suitable for obtaining the maximum uniform oil-quenched hardenability from low and medium alloy steels.

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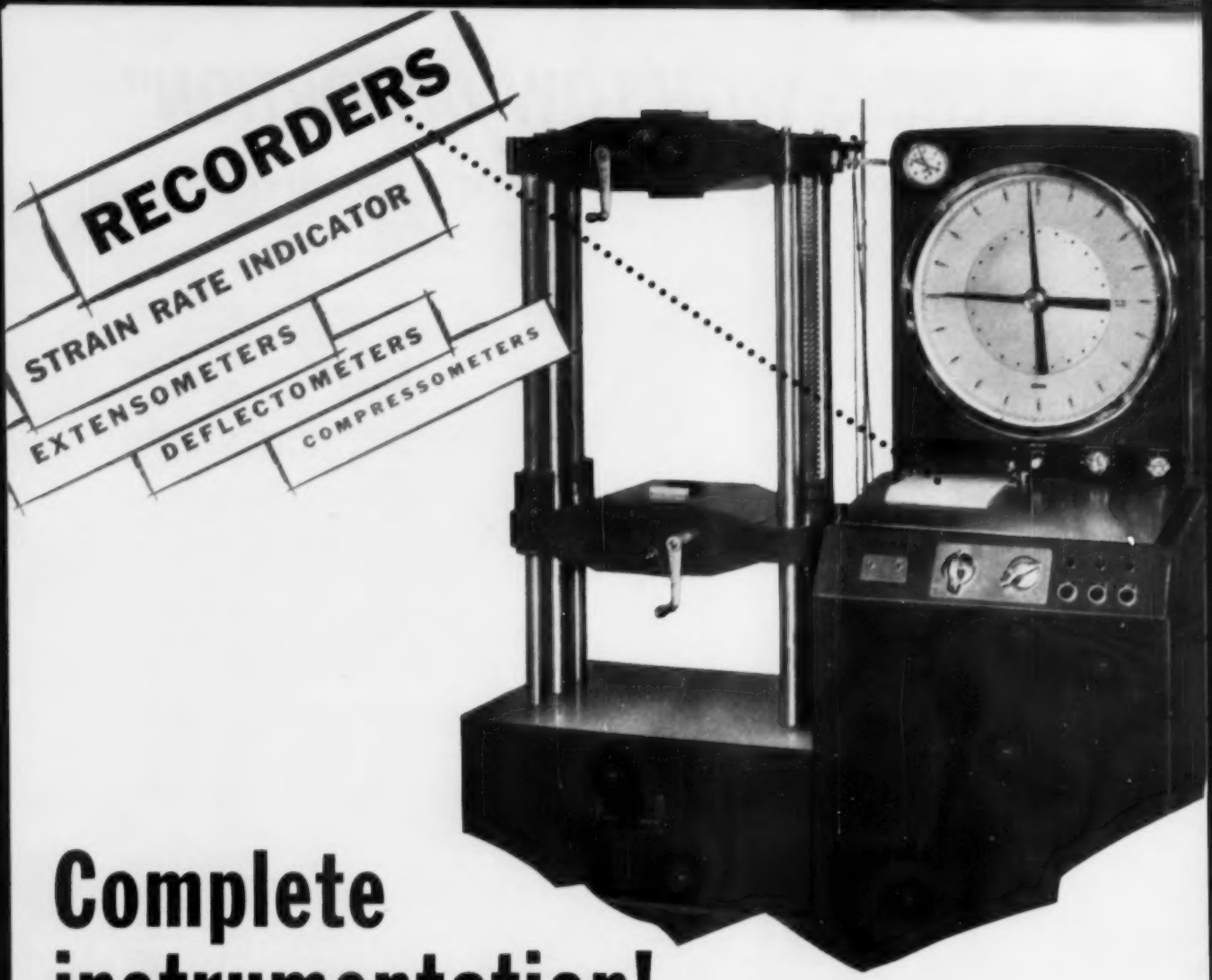

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APPLICATION and EQUIPMENT new products

Tube-in-Strip

A new mill product in the form of a single strip, or sheet, of solid copper, brass or aluminum in which tubes are inflated to desired running lengths in a variety of shapes or sizes has been announced by Revere Copper and

Brass, Inc. The new product has applications in the heat exchange field, including refrigeration and air conditioning, chemical, food and petroleum processing, automobile radiators. Except for the expandable portions, the metal is a solid strip of metal derived from a suitably treated casting and the product does not consist of two pieces of metal brazed, welded and rolled together. The metal can be stamped or drawn into desired shapes prior to the expansion of the channels. The expanded channels can be made circular in section, or during the expansion operation the metal can be forced into dies for the purpose of producing other than circular sections. It is also possible to inflate channels on one side of the strip or sheet only, leaving the other surface flat.

For further information circle No. 569 on literature request card, page 32-B.

Cadmium Plating

A new process for bright cadmium plating in still tanks has been announced by Hanson-Van Winkle-Munning Co. Cadalume makes bright dips unnecessary, although it will take conversion coatings. Although the deposit is bright as deposited on deeply recessed work, a 1% nitric acid bright dip may be used to brighten low current density areas. Most conventional cadmium solutions, or a bright cadmium bath, can be converted to the Cadalume process by adjusting the solution and adding the required amount of addition agent.

For further information circle No. 570 on literature request card, page 32-B.

Portable Welder

A portable welding machine designed specifically for manganese steel and hardfacing work on irregularly-shaped parts has been announced by the Amsco Div. of American Brake Shoe Co. The welder is mounted on large casters and is designed to plug into a-c or d-c welding units by a single cable. It operates on a current range of from 150 to 450 amp. As an

Largest Vacuum Melting Furnace

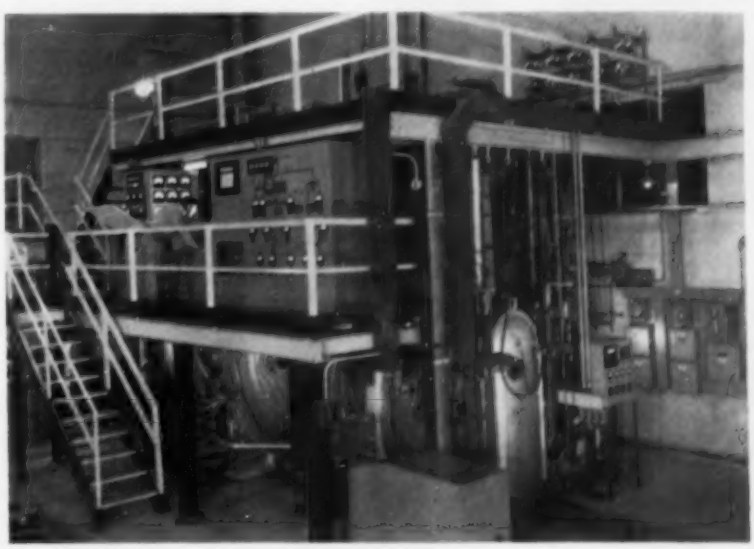
This new 2200-pound vacuum melting furnace was tapped in recent weeks at the Syracuse plant of Vacuum Metals Corp., which is jointly owned by Crucible Steel Co. of America and National Research Corp.

The design, which was based on five years of operating experience with such semi-continuous vacuum furnaces, was by the Research Div. of National Research. The furnace was built by the Equipment Div. of National and installed by the engineering department of the Sanderson-Halcomb Works of Crucible Steel.

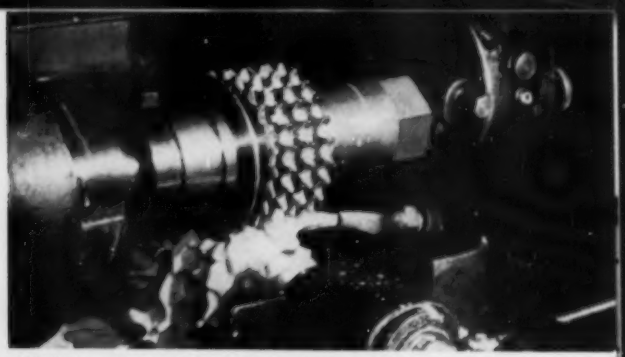
The furnace is remotely operated by the melter, who can control from one console the charging, mold transfer and pouring operations. The melting unit is enclosed in a ¾-in. thick airtight and liquid cooled stainless steel chamber, with connecting air lock chambers for charging raw materials and discharging ingots. Design makes it possible to charge melt, pour and remove ingots without affecting the vacuum in the melting chamber. The mold-handling mechanism makes it possible to cast ingots of varying size and shape, either singly or in multiples from a single heat.

This new unit increases by 60 to 75 tons the monthly potential supply of vacuum melted metal for industry.

For further information circle No. 571 on literature request card, page 32-B.



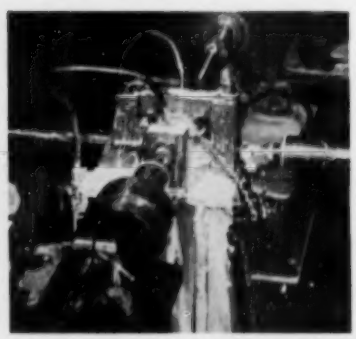
TURNING AND DRILLING. During the machining of a 9-in. piece using carbide-tipped tools, S.E.C.O. removes heat fast ...assures long runs, top speeds.



HOBBING. Flooding the cutting edges of a high-speed-steel hob working 1117 steel, S.E.C.O. provides lubricity and cooling power needed for long tool life.

CENTERLESS GRINDING. In grinding 4320 H steel pins, S.E.C.O. keeps wheels clean. Grinding dirt drops out quickly...is not recirculated. Parts are rust-protected.

SUNOCO EMULSIFYING CUTTING OIL HANDLES 4 TOUGH JOBS...EASILY



DRILLING AND REAMING. On steel forgings with a 350/400 Brinell, S.E.C.O. keeps drills cool...gives clean cutting.

Whether you are shaping, hobbing, grinding, reaming, boring or milling, it will pay you to look into the advantages of SUNOCO EMULSIFYING CUTTING OIL.

Moderately priced, S.E.C.O. has been industry's most widely used soluble cutting oil for years. Higher-than-ever machining efficiency, increased detergency, easier mixing, and other added advantages are helping keep S.E.C.O. the leading emulsifying cutting oil in the country today.

For complete information about S.E.C.O. see your Sun representative. Address SUN OIL COMPANY, Philadelphia 3, Pa., Dept. MP-3.

INDUSTRIAL PRODUCTS DEPARTMENT

SUN OIL COMPANY

Philadelphia 3, Pa.

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SUNOCO

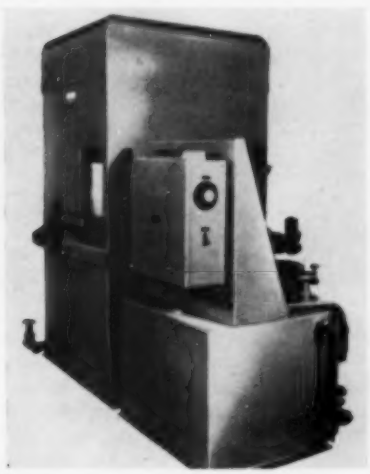
accessory for hardfacing, the welder serves as a semi-automatic device for feeding flux-coated welding wire to parts of machines, or implements, being resurfaced with new metal. The welder features a self-feeding mechanism for keeping the welding arc supplied with welding wire at a rate

proportional to the size of the arc. A conical hopper is mounted above the welding wire outlet as a means of storing and feeding flux. The flux adheres to the wire by the magnetic field created by welding current, and each 1-qt. refill from the hopper serves for 15 min. of welding.

For further information circle No. 572 on literature request card, page 32-B.

Degreaser

Manufacturers Processing Co. has announced a new degreaser for small parts and chips. They are moved in a "corkscrew", circular uphill action, passing through a liquid immersion, liquid rinse, and solvent vapor zone. Clean parts are discharged through an unload chute located 42 in. from ground level. This Vibra-Degreaser action is made possible by a combination of flexible, vibrating leaf springs and electro-magnets to which the spiral trough is attached. The assembly is energized by a pulsating current creating the vibration that transports the work through the cleaning cycle and on to the unload chute.

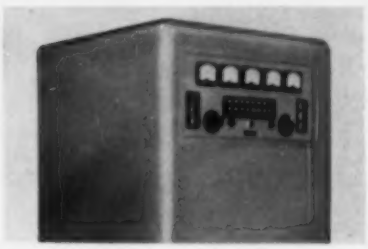


Vibra-Degreaser is capable of cleaning up to 3,000 lb. of chips or metal parts per hour and requires 5 x 5 ft. of floor space.

For further information circle No. 573 on literature request card, page 32-B.

Induction Heating Equipment

A new control station for use in conjunction with remote station and motor generator equipment of either 960, 3000 or 9600 cycles and ranging in power output from 30 to 300 kw. has been announced by the High Frequency Heating Div. of Lindberg Engineering Co. It can be employed in all heat treating processes. A constant check is maintained on air temperature, water temperature, high voltage door interlocks, water-flow



and other operating conditions of both motor generator set and heating stations. A special selector switch enables complete testing of control circuit and checking of protective devices without operating the generator.

For further information circle No. 574 on literature request card, page 32-B.

Creep Testing

Four basic types of creep tests can be performed on a newly designed creep testing machine of 20,000 lb. capacity announced by the Baldwin-Lima-Hamilton Corp. The new machine, with different subassemblies, can be used for long time creep tests and for creep-rupture tests. The same basic creep machine with different components can also be used for relaxation tests and constant strain rate tests. An improved furnace provides for tests up to 1800° F. It is of tubular type 16-in. long and has thermocouple for heat measurement and control. Creep measurements can be made inside the furnace by means of an optional extensometer attached to the specimen over a 3½-in. gage length. It has a range of 2 in. A strip-chart recorder for time vs. elongation can be used with the machine, taking creep measurements from either extensometer or loading screw pick-up.

For further information circle No. 575 on literature request card, page 32-B.

Flaw Tester

A new ultrasonic-transmission testing device for detecting laminar flaws in metals, cupping in bolts, brazing defects and similar discontinuities has been developed by Branson Instruments. The part to be tested is immersed in a liquid and continuous ultrasonic waves are passed through it from the transmitting transducer to the receiving transducer. Discontinuities in the part reduce the amount of energy picked up by the receiving transducer and this reduction, in turn, is registered in a meter reading. A predetermined acceptable quality level may be set. Indicating lights are provided for differentiation of good and bad parts in high-production testing.

For further information circle No. 576 on literature request card, page 32-B.

Cut-Off Machine

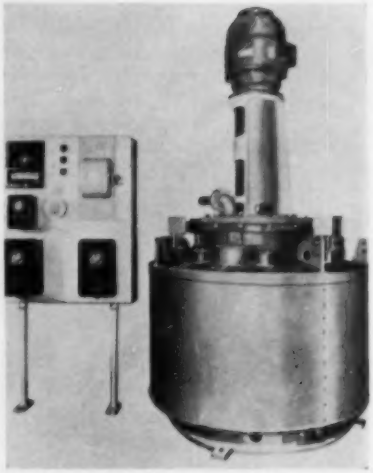
Klaus Machine & Mfg. Co. has announced a machine using standard components for cutting off extruded

materials. Air cylinders, controlled by microswitches, actuate the rolls and cut-off blade. Speed is dependent on the rate of extrusion. The extruded material is looped before it reaches the roll feed. A microswitch at the end of the conveyor stops the machine if the loop is taken up. Any extruded metal that can be sheared can be accommodated.

For further information circle No. 577 on literature request card, page 32-B.

Heat Transfer System

A unit, employing eutectic heat transfer salt and especially designed for heating metal-forming dies has been announced by American Hydrotherm Corp. Temperatures up to 1000° F. can be produced at no pressure. Close control of temperature can be maintained at the point of application. The salt used is nontoxic, noncorrosive, nonfouling and chem-



ically stable. Units are manufactured by Bethlehem Foundry & Machine Co. and come complete with salt pump, tank, piping and instrumentation.

For further information circle No. 578 on literature request card, page 32-B.

Specimen Polishing

Buehler, Ltd., has announced an automatic polishing attachment for metallurgical specimens. The low cost unit is designed to fit all Buehler 8 in. low speed polishers. It accommodates

six mounted specimens of 1 in. diameter, or 5 of 1¼ in. diameter. The complete polishing procedure for the group of specimens requires about 20 min. Satisfactory results are attained with samples of different characteristics polished in the same group.

For further information circle No. 579 on literature request card, page 32-B.

Castable Refractories

Two new hydraulic setting, castable refractories have been announced by the Robinson Clay Product Co. Robinson Flint Cast 29, a high strength castable approximately twice as strong as regular castables, is intended for forming hearths, doors and supported roofs. It also has a higher melting

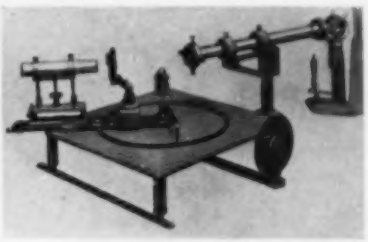
point and a service limit of 2900° F. Robinson Flint Cast 30 is a medium-strength castable with a high service

limit of 3000° F. These two refractories are compounded with a base of calcined material, which does not require heat to harden.

For further information circle No. 580 on literature request card, page 32-B.

X-Ray Diffractometer

New Brunswick Scientific Co. has announced a double crystal X-ray diffractometer for the study of crystal structure. The beam emerging from the X-ray tube, is reflected from a perfect crystal into the long collimator. This perfect crystal functions as an analyzer for any test crystal being investigated. The resolution of the



monochromatized beam is increased further by screening out the alpha-2 component by means of slit systems at each end of the collimator. A Geiger counter and the photographic unit are used to disclose the substructural details of the test crystal.

For further information circle No. 581 on literature request card, page 32-B.

Grinding Fluid

A liquid chemical grinding aid which will prolong the cutting life of abrasive belts and also provide a superior surface finish has been announced by the Coated Abrasives Div. of Armour & Co. Armor-Kut (R) is a heavy red liquid. It is used most conveniently at temperatures near 120° F. This temperature is achieved by means of an immersion heater in the oil reservoir of the grinding machine. Best results are obtained by introducing the liquid as a stream onto

the surface of the belt just prior to the contact with the work. It offers savings in titanium grinding.

For further information circle No. 582 on literature request card, page 32-B.

Thickness Gage

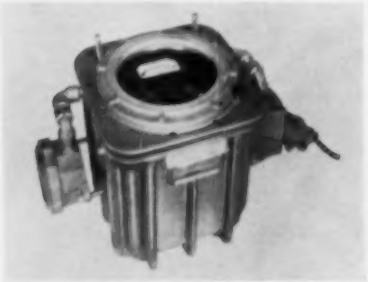
A new ultrasonic measuring device for nondestructive testing has been announced by Alcar Instruments, Inc.

The new gage gives visual indications of material thickness and requires access to only one side of the measured work. Any flaw due to discontinuity or lack of bonding is indicated by a shift or disappearance of the thickness reading. It consists of an oscillator, cathode ray oscilloscope and transducer which transmits ultrasonic vibrations into the tested material. Entire unit weighs about 50 lb. Power required is 115 volts, 60 cycles.

For further information circle No. 583 on literature request card, page 32-B.

Atmosphere Explosion Meter

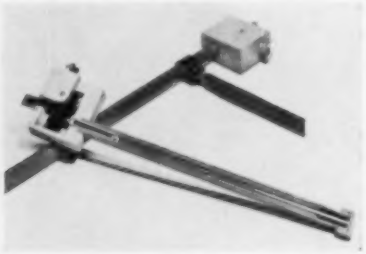
A self-contained portable analyzer and alarm system for combustible gases has been announced by Davis Instruments. The instrument is designed for use in or near hazardous locations. It is a continuous sampling system operated by motor-driven pump mounted inside the unit. The instrument's operating power is 110 v., 60 cycle, single phase, 100 w.



For further information circle No. 584 on literature request card, page 32-B.

Plating Equipment

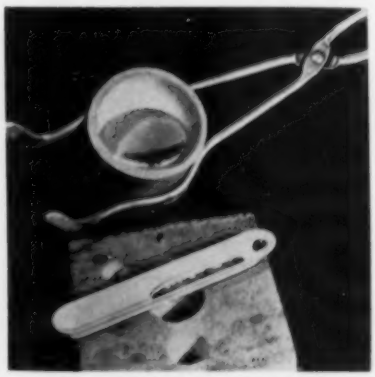
A new temperature regulator for plating baths, which will not deteriorate in acid, has been announced by the Elkhart Controls Co. Its body is constructed of an acid-proof, temperature-sensitive thermoplastic. Utilizing the expanding and contracting properties of this material, which is also a thermal conducting medium, the Eltemp automatically regulates the operation of heating or cooling sources to a temperature tolerance of ±1° F. in a constant solution level. The long thermal tube extends deep into the plating solution and compensates for temperature changes wherever they occur.



For further information circle No. 585 on literature request card, page 32-B.

Laboratory Equipment

A new crucible of borolite zirconium boride 101, a cermet, and with good high-temperature and corrosion-resistant properties has been announced by Fisher Scientific. It has a melting point of 3900° F. The stress-to-rupture life at 1800° F. and 14,000 psi. is 1000 hr. in still air. The new crucible is available in a 50 and 100-milliliter sizes.



For further information circle No. 586 on literature request card, page 32-B.

New Rokide* Coatings Resist Heat and Abrasion

Rokide spray coatings help solve many high temperature and wear problems

WITH the rapid increase in modern high temperature applications there has been a corresponding increase in demands for resistant materials. Norton ROKIDE spray coatings are meeting such demands with great success. These hard, adherent crystalline refractory oxides offer many important advantages. For example:

They are both thermally and electrically insulating . . . Their hardness, chemical inertness and stability in combustion temperatures provide high resistance to excessive heat, abrasion, erosion and corrosion. Their high melting points and low thermal conductivities reduce the temperatures of the underlying materials and permit higher operating temperatures.

ROKIDE Coatings vs. Stainless Steel

Analyses of Norton ROKIDE spray coatings and of stainless steel reveal interesting comparisons. While less dense than the bare steel, the ROKIDE coatings are very much harder, have considerably higher melting points and are very much lower in thermal conductivity and thermal expansion.

Proof

There are three Norton ROKIDE coatings: ROKIDE "A" aluminum oxide, ROKIDE "ZS" zirconium silicate and ROKIDE "Z" stabilized zirconia. Thoroughly proved in such critical applications as reaction motors, as well as in AEC projects, the value of these coatings to a broad range of more conventional applications is obvious.

Applications

The versatility and adaptability of ROKIDE coatings are evident in the following list of applications, actual and suggested:

Baffle plates . . . bearing surfaces . . . mechanical seals . . . feed rolls . . . metal treads . . . thermal barriers . . . reflection coatings . . . coatings for exhaust ports, duct linings, ladles and crucibles . . . insulation for copper busbars, circuit breaker components, thermocouple wires and tubes, large and small electronic equipment . . . protection for nozzles, valve plugs, piston heads, pump shafts, gas turbine parts, etc.

Although ROKIDE coatings are most commonly applied to metals they are effective on other materials, such as ceramics and certain plastics. Thicknesses of the coatings generally range from .005" to .05".

Other Norton Electric Furnace Materials

are products made of CRYSTOLON* silicon carbide (including ROKIDE "C" coating for graphite parts and CRYSTOLON "N" monolithic shapes), ALUNDUM* fused alumina, MAGNORITE* magnesium oxide, NORBIDE* boron carbide and Fused Stabilized Zirconia. These high-melting materials are also the basic ingredients of the famous Norton Rx's — refractories *engineered and prescribed* for the widest range of uses.

For more detailed information on ROKIDE coatings, use the coupon.

ROKIDE Spray Coatings are applied in a molten state by means of a metalizing type spray gun. The oxide is fed into the gun in rod form at a carefully controlled rate. The coatings can be applied to parts of any size and to all shapes accessible to the spray gun equipment.

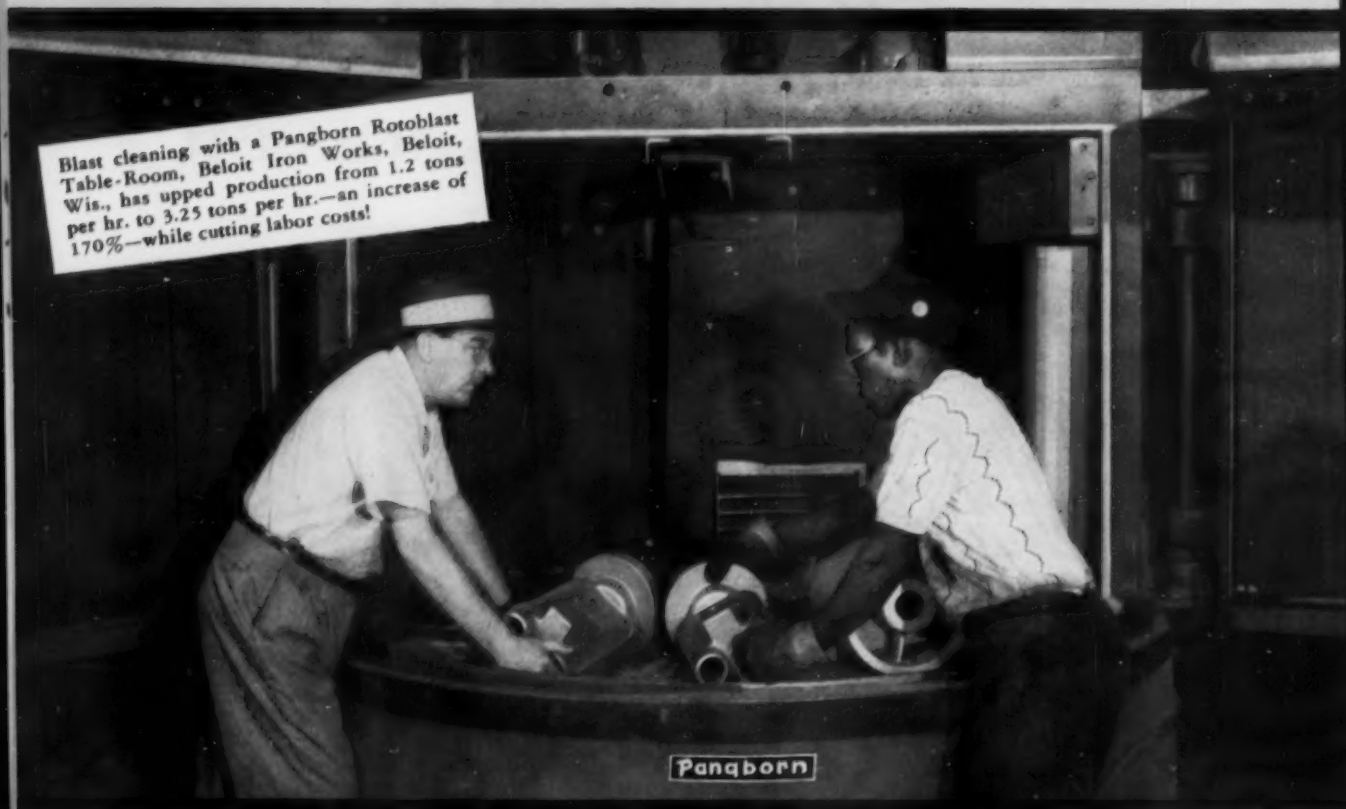
NORTON
REFRACTORIES
Engineered... Rx... Prescribed
Making better products... to make your products better

*Trade-Marks

NORTON COMPANY, *Refractories Division*
322 New Bond Street, Worcester 6, Massachusetts
Please send me further facts on ROKIDE coatings.

Name..... *Company*.....
Street.....
City..... *Zone*..... *State*.....

Pangborn Rotoblast® speeds production at Beloit Iron Works!



Blast cleaning with a Pangborn Rotoblast Table-Room, Beloit Iron Works, Beloit, Wis., has upped production from 1.2 tons per hr. to 3.25 tons per hr.—an increase of 170%—while cutting labor costs!

And at Link-Belt, too!

Faster cleaning with Blastmaster Rotoblast Barrel at Olney Foundry Division, Link-Belt Company, Philadelphia, has stepped up production 20% to 25%!

Tables, rooms, barrels—whichever blast cleaning machine best fills your cleaning needs, Pangborn Rotoblast will speed *your* production.

Pangborn Rotoblast cuts operating time by cleaning *quickly,* throwing a heavy volume of abrasive over a large surface area. The result is higher production and, therefore, lower cleaning costs. Add the "plus" benefits of reduced labor costs and better cleaning quality and we think you'll agree Pangborn Rotoblast is worth investigating. Take a few seconds now to send for more information—it can save you thousands of dollars later.

Write for Bulletin 227 to PANGBORN CORPORATION, 1800 Pangborn Blvd., Hagerstown, Md. *Manufacturers of Blast Cleaning and Dust Control Equipment.*

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BLAST CLEANS CHEAPER


Rotoblast Blastmaster® & Continuous-Flo Barrel


Rotoblast Tables & Table-Rooms


Special Blast Rooms & Cabinets


Pangborn Dust Control Equipment


Malleabrasive® Shot & Grit

Distributors for Malleabrasive and Tru-Steel Abrasives

A Significant Announcement By AECco

RALPH E. VanDEVENTER FRANK FAERY C. Q. SWENSON ARTHUR L. LaMASTERS C. E. SWENSON

THANK YOU "DETROIT"! WE are PROUD that your rewards and challenge let AECco put more, PROVEN, ENGINEERS on your AUTOMOTIVE PRODUCTION TEAM!

I join Frank Faery and our Field Engineers, and our Design, Production and R & D teams at Champaign, in welcoming the Swensons! We proudly announce that their recognized experience and engineering talent are at your service, in full cooperation with Frank Faery. "CQ" and "CE" who started January 1, were too "swamped" with customers' orders, inquiries, and incidentally, congratulations, to pose for this photo earlier. Frank has, since April, 1946, most ably represented AECCo in the Detroit area.

I have asked Ralph VanDeventer to state his concept of automotive production requirements of High-Temperature-Tooling. Many of you have known "Van" during his 18 years as Chief Metallurgist of Packard Motor Car Company, Detroit. "Van", as Vice President of AECCo, directed unprecedented, comprehensive casting-design-process-metallurgical R & D and pilot production at Champaign since December, 1954. You'll hear more about that.
—Arthur L. LaMasters, V. P., Sales

Automotive metallurgists and production men know that the "beating" that high temperature tools take in continuous service must be *lived-with* to *fully appreciate*. The cyclic heating and quenching — under severe loads — and the associated expansions and stresses, create critical jobs that call for the best of high temperature tooling. Certainly such tooling does as much work per pound of metal and per hour of life as any metal in man's service.

The pressures of automotive production are not apt to be forgotten after 20 years in Detroit battle lines. Production, — cars per hour, cars per week, engines to schedule — the pressure to "get production" is a Detroit trademark. Costs — cents per car, percent efficiency, direct and indirect, and overhead budgets — pressures to get costs down and keep them down are never relaxed. Troubles which delay production and cost money multiply pressure. I know these feelings from personal experience, and I also know the *appreciation* that production men have for well engineered, skillfully made high-temperature tools that *dependably do their job month-after-month, and year-after-year.*

At AECCo. the same attention is given to design detail, and to the "tremendous trifles" of foundry practice, that you would give them yourself — if you had the many years of experience that our staff has acquired in this most complex, and highly specialized field. Incidentally, lessons learned in our R & D work to advance aircraft castings (which have beaten much heavier current forgings on stress tests) are being applied as fast as practicable on commercial high-temperature-tooling and "stainless". If you want us to share some of your production and cost pressure — competently, effectually — say the word, and your jobs will get "*the full treatment*". — R. E. VanDeventer, V.P.

FRANK FAERY grew up on the Detroit heat-treat team, in Metallurgical field service to the industry. He was a partner in a large modern heat-treat plant, stepping out at War's end. Has since represented AECCo. C. Q. Swenson has, for 20 years, engineered, sold, and serviced "Michiana" alloys. His son, C. E. Swenson, — with time out as a Navy pilot, — has "followed in 'C. Q.'s' footsteps and beaten some paths of his own in the alloy field". Both Swensons and Ralph VanDeventer are U. of M. alumni.

ARTHUR L. LaMASTERS, Vice President, (since 1945) spent about 2 years in Detroit, — "to bring our management closer to Detroit's alloy problems".

We welcome your inquiries for ENGINEERED "Accoloys" in any Hi-Heat and/or heat corrosion applications. — The tougher — the better.

Alloy *Engineering* and Casting Co.

CHAMPAIGN, ILLINOIS
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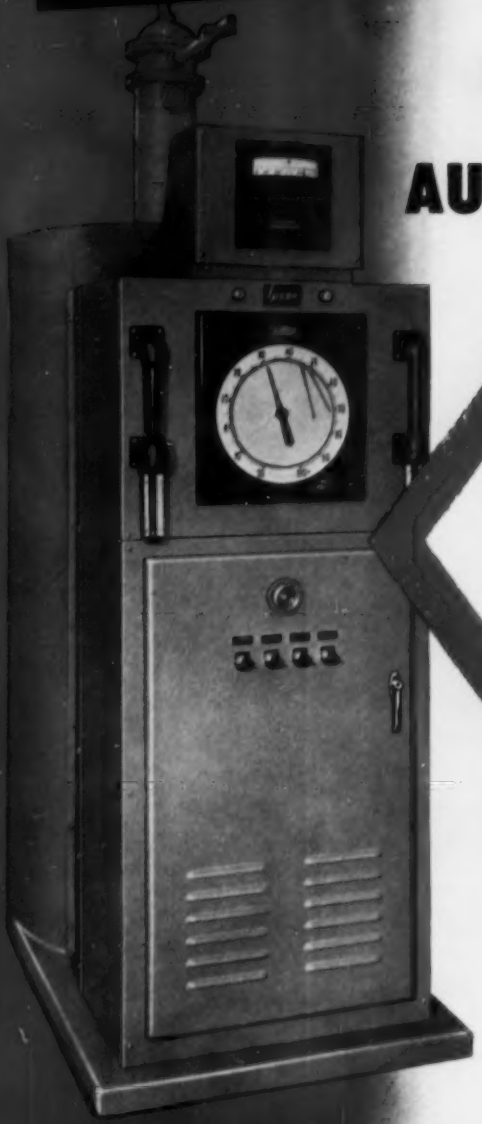
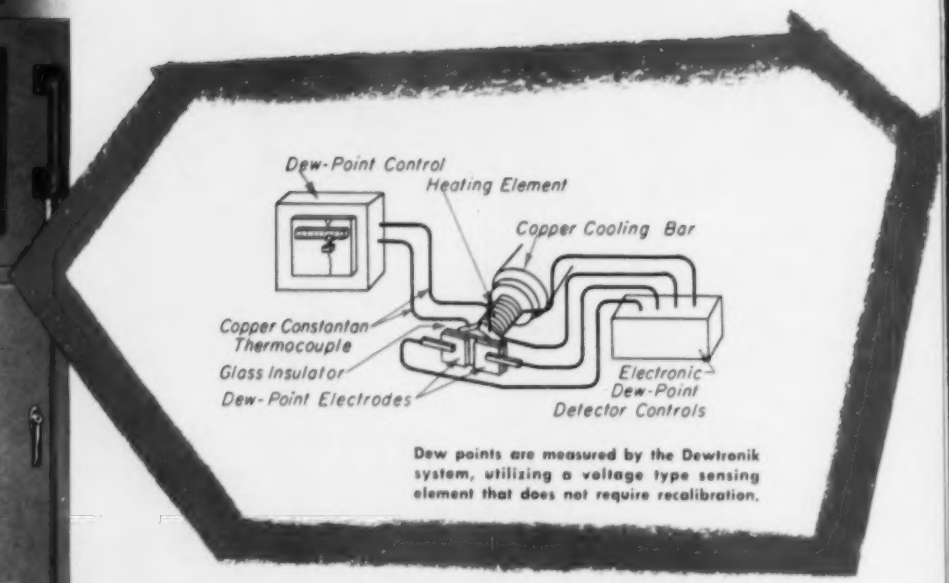
new convenience and accuracy in heat treating.

NEW ENDOTHERMIC GENERATOR PROVIDES AUTOMATIC RATIO CONTROL





Dew points are measured by the Dewtronik system, utilizing a voltage type sensing element that does not require recalibration.

A unique and more efficient means to obtain precise atmosphere control is now offered industry in the new Ipsen Automatic Endothermic Generator. By combining a dew point controller with the generator, several important advantages are realized, and scope of operations is materially increased.

- **Generated gas is controlled within a very narrow dew point range through automatic regulation of the air/gas ratio.**
- **Humidity changes, variations in line pressure and other operating conditions are compensated for automatically.**
- **Need for a control technician is minimized by elimination of manual adjustments and periodic dew point checks.**
- **Periodic burnouts and downtime for maintenance are minimized.**

Standard units are available for capacities from 750 to 5000 cfh. Write for complete information.

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AUTOMATIC Ipsen HEAT TREATING UNITS

APPLICATION and EQUIPMENT new literature

590. Abrasion Tester
Bulletins on durable precision instrument for evaluating the resistance of surfaces to rubbing abrasion. *Taber Instrument*

591. Abrasive Cleaning
Catalog 54-W on brush types, sizes, speeds, filaments. Aids to power brush selection. *Pittsburgh Plate Glass, Brush Div.*

592. Abrasive Wheels
Operating suggestions and recommended wheels for finishing stainless. *Manhattan Rubber Div.*

593. Adhesives
Data chart gives form, percent solids, viscosity, time and curing temperature for line of adhesives. *Rubber and Asbestos Corp.*

594. Alloy Cast Iron
64-page bulletin A-71 on engineering properties and applications of Ni-Resist. Corrosion data compared with gray cast iron. *International Nickel Co.*

595. Alloy Castings
Bulletin 3150-G on castings for heat, corrosion, abrasion resistance. *Duraloy*

596. Alloy Chart
Comparison of AISI, SAE, ACI, AMS, WAD and PWA chromium and chromium-nickel stainless specifications. *Cannon-Muskegon*

597. Alloy Selection
Chart to select alloy for given corrosive problem. 350 corrosives included. *Cooper Alloy Foundry*

598. Alloy Steel
16-page book on type 9115 low-alloy high-strength steel. Properties, fabrication, welding. *Great Lakes Steel*

599. Alloys
8-page bulletin on composition, properties and applications of series of 12 copper-nickel-base alloys available in cast form. *Waukesha Foundry*

600. Aluminum
12-page booklet on extruded shapes, tube and pipe, coiled sheet, forgings and properties of aluminum alloys. *Revere*

601. Aluminum Alloys
New booklet on how to melt and cast aluminum alloys. *Geo. Sall Metals*

602. Aluminum Bronze
8-page booklet on aluminum bronze bearing material which is forgeable, corrosion resistant, lightweight. *Mueller Brass*

603. Aluminum Die Castings
Bulletin on design and manufacture of aluminum die castings. *Hoover Co.*

604. Aluminum Finish
Bulletin on new invisible finish for aluminum describes Alodine No. 1000 and includes flow sheet for immersion process. *American Chemical Paint*

605. Aluminum Heat Treating
8-page Bulletin 5912 on solution heat treating, annealing, stabilizing and aging of aluminum. *General Electric*

606. Aluminum Melting
Folder on electric furnaces for the aluminum alloy foundry. *Ajax Engineering*

607. Aluminum Strip
20-page booklet on how it is made, sizes and weights of coils. Technical data on aluminum alloys used. *Scovill*

608. Atmosphere Furnace
Information on mechanized batch-type atmosphere furnaces for gas cyaniding, gas carburizing, clean hardening or carbon restoration. *Dow Furnace*

609. Atmosphere Furnace
12-page bulletin on electric furnaces with atmosphere control for hardening high speed steel. *Sentry*

610. Atmosphere Furnace
Bulletin on controlled atmosphere furnace. *Industrial Heating Equipment*

611. Atmospheres
Bulletin on generator for producing pure nitrogen with a controllable hydrogen content. *Baker & Co.*

612. Basic Materials
24-page booklet on Alundum, Crystolon, Magnorite, Norbide, zirconia, carbides, borides and other basic materials. Products made from them are listed. *Norton*

613. Basic Steelmaking
12-page bulletin on how to make basic electric steel. References. *Basic Refractories*

614. Bearing Alloys
Bulletin No. 18 on sintered bearings lists design requirements, metallurgical considerations and alloys and their properties. *U. S. Graphite*

615. Bearing Bronze
6-page folder on advantages of continuous cast bearing bronze and how it is made. *American Smelting & Refining*

616. Beryllium Copper
How beryllium copper is used for parts for taxi cab meters. *Beryllium Corp.*

617. Beryllium Copper
Bulletin 1 on available alloys, conditions, tempers and tables of sizes and properties. *Penn Precision Products*

618. Beryllium Nickel
4-page leaflet on high-strength, corrosion-resistant beryllium-nickel casting alloys. *Beryllium Corp.*

619. Black Oxide Coatings
8-page booklet on black oxide coatings for steel, stainless steel and copper alloys. *Du-Lite*

620. Boiler Refractories
20-page bulletin on boiler refractories discusses basic requirements of refractories, what causes refractories to fail, various kinds of insulating firebrick. *Refractories Div., Babcock & Wilcox*

621. Boron Carbide
New data book on boron carbide and elemental carbide for use in atomic energy field. *Norton Co.*

622. Brazing
Bulletin 124—on salt bath brazing process—shows how it is possible to substitute brass for copper and develop joints of adequate strength for most steel assemblies. *Ajax Electric*

623. Brazing Alloys
Bulletin on application of six types of copper and silver brazing alloys. *United Wire & Supply*

624. Bright Hardening
No. 3, Vol. 6 of Heat Treat Review on commercial bright hardening of stainless steel at Syracuse Heat Trent Corp. *Surface Combustion*

589. Powdered Metals

Tables, graphs and pictures illustrate the applications and properties of powdered metal parts in this 52-page engineering

manual. A large section on design gives features to consider such as tolerances, effects of temperature, installation and sizing and redesigning for powder metallurgy. Machining is discussed in detail. *Amplex Div.*

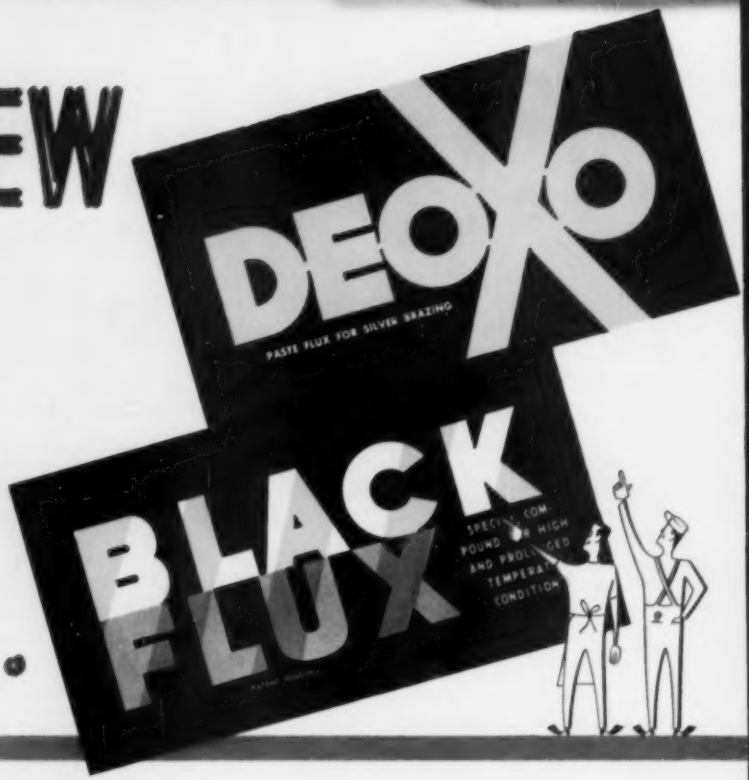
625. Brinell Machine
Data on semi-automatic Brinell testing machine. *Detroit Testing Machine*

626. Buffing and Polishing
24-page catalog on cutting, coloring and double duty compounds for 12 metals, plastics and rubber. *Hanson-Van Winkle-Munning*

627. Carbides
4-page bulletin describes tungsten carbide grades for cutting nonferrous metals and cast iron, for cutting steel, for die applications and special purpose grades. *Adamas Carbide Corp.*

628. Carbon and Graphite
20-page catalog on carbon and graphite applications in metallurgical, electrical, chemical, process fields. *National Carbon*

2 GREAT NEW SILVER BRAZING FLUXES...



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Four standard APW formulae (APW1100, APW-1200, Deoxo and Black Flux) are available to simplify selective fluxing for you, to insure complete efficient protection in any classification of silver brazing. They enable the technician to key the selection of flux to the precise requirements of the job in production.

A "Complete Guide To Selective Fluxing" will be sent you upon request. It contains complete, factual data that you should know. If you wish, an expert Silvaloy Technician will be glad to consult with you, at your convenience. Call the Silvaloy Distributor in your area or write us directly. ★ ★ ★ ★ ★ ★

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629. Carburizing
Bulletin on carburizers for pack carburizing. *Park Chemical*

630. Carburizing
16-page booklet on gas-carburizing processes and equipment. Discussion of suspended carburization, carbon restoration. *Surface Combustion*

631. Chromate Finishing
File on chromate conversion coatings for prevention of corrosion and paint-base treatment of nonferrous metals. *Allied Research Products*

632. Chromium Plating
4-page bulletin on new "crack-free" chromium plating process. *United Chromium*

633. Cleaning
Folder on di-phase cleaning gives equipment, construction features, spray and blow-off features, heating systems. *Solventol*

634. Cleaning Aluminum
12-page bulletin on cleaning process for preparing aluminum and magnesium for welding. *Northwest Chemical*

635. Coatings
Folder on Kelite 25, paint bonding coating. *Kelite*

636. Combustion Control
20-page booklet on combustion of various fuels and portable instrument to measure content of oxygen and combustibles. *Cities Service Oil*

637. Compressors
12-page bulletin 126-A on application of turbo compressors to oil and gas-fired equipment used in heat treating, agitation, cooling, drying. Performance curves, capacities. *Spencer Turbine*

638. Control Station
Bulletin 1490 on controls for motor generator for induction heating. *High Frequency Heating Div., Lindberg Eng. Co.*

639. Controllers
12-page booklet on temperature controls and special purpose controllers. Operation, design, installation. *Assembly Products, Inc.*

640. Controllers
48-page bulletin P1260 on pyrometers, thermometers, control valves for furnaces, ovens, dryers. *Bristol*

641. Controllers
16-page educational bulletin No. 9 gives data, operation diagrams, schematic drawings of capacitrols. *Wheelco Instruments*

642. Copper Alloys
40-page handbook on phosphor bronze, nickel silver, cupro nickel, beryllium copper. *Riverside Metal*

643. Copper Alloys
64-page book on free-cutting brass, copper and bronze. *Chase Brass*

644. Corrosion Resistant Alloy
Data sheet compares corrosion properties of Elgiloy and stainless steel. *Elgin National Watch Co.*

645. Creep Testing
Data on operation and instrumentation of Arcweld lever arm creep testing machine. *Minneapolis-Honeywell*

646. Cut-Off Wheels
36-page revised manual on cut off machines and abrasive wheels. *Norton Co.*

647. Cutting Oil
Bulletin 963 on transparent cutting oil which is designed for use on a wide variety of steels. *Sun Oil Co.*

648. Descaling
Bulletin on new machines for descaling steel sheets, plates and coils after hot rolling or heat treating. *Pangborn Corp.*

649. Descaling Process
8-page bulletin on sodium hydride descaling process for ferrous and nonferrous metals. *DuPont*

650. Descaling Stainless Steel
Bulletin 25 on descaling stainless steel and other metals in molten salt. *Hooker Electrochemical*

651. Dew Point Control
Bulletin No. 21-C on instrument which indicates, records and controls dew point automatically. *Ipsen*

652. Die Casting Machines
New illustrated brochures gives special features and illustrates various die casting installations and parts which can be run. *Lester Phoenix*

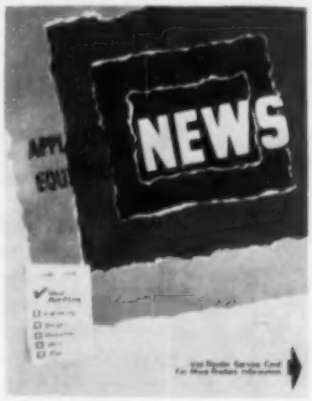
653. Dynamometers
4-page folder on precision dynamometers for measuring traction, tension or weight. Capacities from 0 to 500 lb. to 0 to 100,000 lb. *W. C. Dillon*

654. Electric Furnace
Bulletin on box-type, pre-heat and hardening furnace with automatic atmosphere contamination control. *Pacific Scientific*

655. Electric Furnaces
Catalog of electric furnaces and ovens for hardening, tempering, annealing, drawing, drying, baking, enameling. *Cooley Electric Mfg.*

588. Product File

More than 60 new product developments, more than 700 important and interesting booklets, bulletins and engineering literature are presented in a convenient 32-page file reference in *Application and Equipment News*. Reprinting all the hundreds of product and lit-



erature items that have appeared in Metal Progress during the first quarter of 1956, this handy summary of what's new in metals, design applications, processing, fabrication and equipment makes an ideal file reference for use throughout the year. This is offered as a special service to Metal Progress readers and is available without charge.

656. Electric Furnaces
12-page booklet on research facilities for building and operating electric furnaces. *Electric Furnace Co.*

657. Electric Furnaces
Bulletin 441 on box-type electric furnaces diagrams and describes the furnaces and lists specifications. *Hevi Duty Electric Co.*

658. Electric Furnaces
Brochure on electric heat treating, melting, metallurgical tube, research and sintering furnaces. *Pereny Equipment*

659. Electric Melting
Bulletin 527 on compact arc furnace. Melt time and power consumption for four alloys. *Detroit Electric Furnace*

660. Electrodes
36-page booklet on low alloy and mild steel electrodes. Engineering tables of SAE steels, preheating temperatures, estimating cost of welding, hardness of welds. *Metal & Thermit*

661. Electropolisher
Bulletin on theory and practice of electrolytic polishing of metallurgical samples. Description of electropolisher. *Buehler*

662. Extrusion
24-page booklet describes heavy press extrusions at Halethorpe, Md. Equipment, operating steps, products. *Kaiser Aluminum & Chemical Sales*

663. Fasteners
64-page catalog of stainless steel fasteners lists 9000 items and sizes in different stainless analyses. *Anti-Corrosive Metal Products*

664. Ferro-Alloys
32-page book tells how ferro-alloys are made and how they are used. *Electro Metallurgical Co.*

665. Finishes
Data sheets on finishes for aluminum, copper, cadmium, zinc and white brass. *Swift Industrial Chemical*

666. Finishes
Pocket-sized booklet covers blackening compounds, alkaline cleaners, strippers, lacquers, enamels, rust removers. *Enthone*

667. Finishing Barrel
Data on new heavy duty barrel for finishing stamped, forged and machined, cast parts. *Lord Chemical*

668. Flame Hardening
20-page catalog on flamatic hardening machines and allied equipment. *Cincinnati Milling Machine Co.*

669. Flame Hardening
Attractive literature discusses flame hardening of large ways, rolls, etc. *Detroit Flame Hardening Co.*

670. Flame Plating
16-page booklet lists advantages, properties, specifications of flame-plated tungsten carbide coating. *Linde*

671. Flow Meter
Specification Sheet 242-2 for mechanical flow meters of the evenly graduated type. *Minneapolis-Honeywell Regulator Co.*

672. Flow Meters
Bulletin 201 on flow meter for gas used in heat treating. *Waukee Eng'g*

673. Forging
20-page bulletin 355 on steam drop hammers. Dimension, designs, construction. *Erie Foundry Co.*

674. Forgings
12-page booklet on how forged weld-

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410	Valve trim, oil refinery equipment, pump shafts.
416	Pinions, gears, shafts, aircraft fittings.
GROUP II	Ferritic—straight chromium, non-hardenable. Machineable. Magnetic. Corrosion resistance superior to Group I.
430	Trim work exposed to atmosphere or water. Hardware.
442, 3, 6	Scale resisting. Furnace parts, baffles, blowers, trays.
GROUP III	Austentic—chromium—nickel—non-hardenable.
302	Heat treating fixtures.
303	Food machinery equipment.
304	Dairy equipment. Magnetic traps.
305	Textile equipment.
309	Chemical equipment. Pump parts.
316	Chemical equipment. Condensers.
347	Pressure fittings.
WAUKESHA METAL	
0	Copper base, high nickel content, corrosion-resisting alloy. For high hardness. High tensile characteristics. Good wearing qualities.
1	Recommended for frictional parts.
3	Rather hard. Recommended for conveyor chain links, cams.
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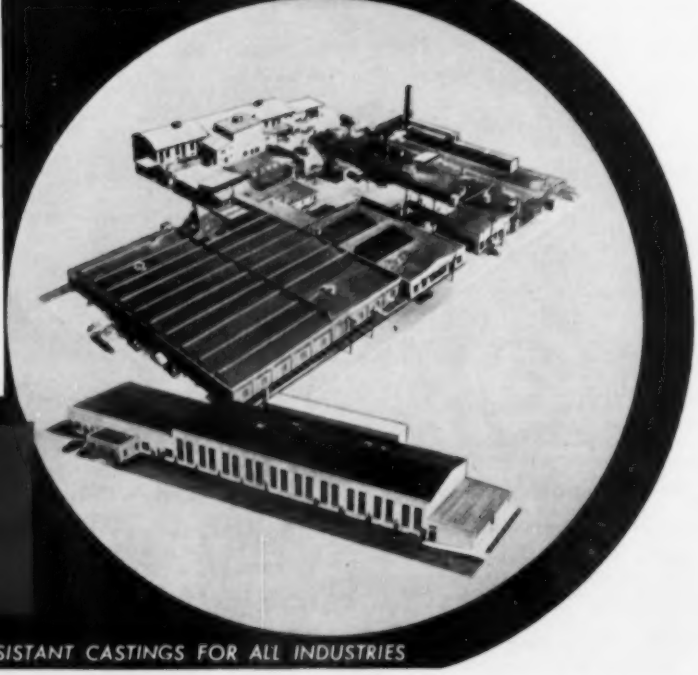

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less rings and flanges are made. Case histories. *Standard Steel Works Div., Baldwin-Lima-Hamilton*

675. Forgings
94-page book on die blocks and heavy-duty forgings. 20 pages of tables. *A. Finkl & Sons*

676. Fuels
8-page booklet tells of the rapid growth and uses of liquefied petroleum gas. *Gulf*

677. Furnace Charging
12-page brochure on eight models of charging machines for heating and melting furnaces. *Salem-Brosius*

678. Furnace Elements
24-page Bulletin H on electric heating elements. Includes extensive tabular data on physical and electrical specifications for various sizes. *Globar Div.*

679. Furnaces
Bulletin on electric heat treating furnaces describes five series and accessories. *Lucifer Furnaces*

680. Furnaces
Series of bulletins on controlled atmosphere, carburizing, nitriding, hardening furnaces. *American Gas Furnace*

681. Furnaces
Bulletin 435 on furnaces for tool room, experimental or small batch production. Gas, oil, electric. Muffle or direct heated. *W. S. Rockwell*

682. Furnaces
High temperature furnaces for temperatures up to 2600° F. are described in bulletin. *Carl-Mayer Corp.*

683. Furnaces
6-page folder on gas-fired, oil-fired and electric furnaces. Typical installations. *Electric Furnace*

684. Furnaces
Data on luminous wall forging furnaces. *A. F. Holden*

685. Furnaces, Heat Treating
32-page catalog on high-speed gas furnaces for heat treating carbon and alloy steels; also pot furnaces for salt and lead hardening. *Charles A. Hones*

686. Gear Tester
New bulletins on testing machines for roll testing of spur, worm, spiral and bevel gears. *Geo. Scherr Co.*

687. Gold Plating
Physical, thermal, chemical, electrical, diffusion and optical properties of electroplated gold. Uses. *Technic, Inc.*

688. Gold Plating
Folder on salts for bright gold plating. Equipment needed. *Sel-Rex*

689. Graphite
6-page revised bulletin No. 435 on colloidal graphite for surface coatings and impregnation. *Acheson Colloids*

690. Graphite Electrodes
Vest-pocket notebook containing 90 pages of information on electric furnace electrodes and other carbon products. *Great Lakes Carbon Corp.*

691. Handling Devices
Pamphlets on clamps for lifting and handling. Their application to various industries. *Merrill Bros.*

692. Hardness Conversion
Celluloid card, 2¾ x 4¾ in., gives approximate relationship between Brinell, DPH (Vickers), Rockwell and Shore Scleroscope hardness values and corresponding tensile strengths of steels. *International Nickel*

693. Hardness Numbers
Pocket-size table of Brinell hardness numbers incorporating other tabular information. *Steel City Testing*

694. Hardness Tester
Bulletin on how to test large gears with portable Brinell tester. *King Tester Co.*

695. Hardness Tester
20-page book on hardness testing by Rockwell method. *Clark Instrument*

696. Hardness Tester
4-page bulletin on tester for both superficial and regular hardness testing. *Torsion Balance Co.*

697. Hardness Tester
Bulletin on Impressor portable hardness tester for aluminum, aluminum alloys and soft metals. *Barber-Colman*

698. Hardness Tester
Data on hardness testing scleroscope with equivalent Brinell and Rockwell C numbers. *Shore Instrument*

699. Hardness Testers
Catalog of testers for normal hardness, superficial testing, accessory and special testing and micro and macro hardness testing. *Wilson Mechanical Instrument*

700. Heat Resistant Castings
16-page bulletin on design, foundry practice and applications. *Electro-Alloys Div.*

701. Heat Treating
16-page booklet on cost accounting for heat treating. *Metal Treating Institute*

702. Heat Treating
Bulletin 14-T on ovens for heat treatment of aluminum and other low-temperature processing. *Young Bros.*

703. Heat Treating Belts
Catalog of convevor belts and data for their design, application and selection. *Ashworth Bros.*

704. Heat Treating Fixtures
12-page bulletin on wire mesh baskets for heat treating and plating. *Wiretex*

705. Heat Treating Fixtures
Folder on carburizing boxes, trays, heat treat fixtures and baskets. *Misco*

706. Heat Treating Fixtures
24-page catalog on heat and corrosion-resistant equipment for heat treating and chemical processing. 30 classifications of equipment. *Pressed Steel*

707. Heat Treating Fixtures
32-page Catalog G-10 covers heat and corrosion resistant fabricated alloy products. Includes furnace muffles, trays, fixtures, retorts, pit-type furnace equipment, salt bath equipment, pickling and plating equipment. *Rolock, Inc.*

708. Heat Treating Furnaces
12-page booklet on various heat treating furnaces contains chronology of advances in heat treating furnaces. *Holcroft*

709. High-Temperature Alloys
Booklet "Keep Operating Costs Down When Temperatures Go Up." *International Nickel*

710. High-Temperature Alloys
"Haynes Alloys for High-Temperature Service" summarizes all available data on 10 superalloys and lists physical and mechanical properties of two newly developed alloys. *Haynes Stellite*

711. Induction Heaters
New bulletin on low-frequency induction heating describes units for brass, copper, titanium, steel, forgings, light metal extrusion presses. *Magnethermic*

712. Induction Heating
12-page Bulletin 13-A on high frequency induction furnace for forging, upsetting.

skinning, annealing, hardening. *Ajax Electrothermic*

713. Induction Heating

Folder on high frequency induction heating for heat treatment, joining and hot forming. Charts on current penetration in steel. *Magnethermic*

714. Induction Heating

8-page bulletin on forging with induction heat includes case histories, benefits to the forging industry. *General Electric*

715. Induction Heating

New 12-page bulletin gives descriptions, technical data on various sizes. Water systems diagrams and standard accessory equipment. *High Frequency Heating Div., Lindberg Engineering*

716. Induction Heating

60-page catalog tells of reduced costs and increased speed of production on hardening, brazing, annealing, forging or melting jobs. *Ohio Crankshaft*

717. Induction Heating Control

New Bulletin HT-1 on automatic temperature control for induction heating equipment. Types of control, components of induction heaters. *Minneapolis-Honeywell*

718. Industrial Heating

20-page handbook classifies industrial ovens and gives pointers on oven selection. *Michigan Oven Co.*

719. Investment Casting

New bulletin on gas fired furnaces for investment casting. Also includes chart of characteristics of typical investment casting alloys. *Surface Combustion*

720. Iron Powders

12-page bulletin No. 2 on how electrolytic and reduced iron powders are made. Parts made, uses. *Plastic Metals Division, U. S. Radiator Corp.*

721. Joining Magnesium

126-page book on welding, adhesive bonding and mechanical joining of magnesium. *Dow Chemical*

722. Joining Stainless

24-page booklet on various welding methods, soldering, brazing, flame cutting and arc cutting of stainless. *Crucible Steel*

723. Laboratory Equipment

20-page catalog of apparatus for chromatography and electrophoresis including balances, colorimeter, densitometer, spectrophotometers. *Harshaw Scientific.*

724. Leaded Steel

8-page booklet on production of lead treated steels, their advantages and case histories of their use. *Copperweld Steel*

725. Liquid Honing

News letter, V. 4, No. 3, explains application of hard chromium plating to machine tools and assistance of liquid honing in producing a good finish. *City Plating Works*

726. Low-Alloy Steel

60-page book on high-strength low-alloy steel, properties, fabrication and uses. *U.S. Steel*

727. Lubricant

8-page folder describes use of molybdenum disulfide lubricant in cold forming, cold heading and other applications. Case histories. *Alpha Corp.*

728. Lubricants

8-page booklet on colloidal greases, forging compounds, hydraulic concentrate and others. *Grafo Colloids*

729. Lubricants

Newly revised 4-page booklet on graphite, molybdenum, disulfide, mica vermiculite, zinc oxide and acetylene black. Carriers, diluents, applications and physical data. *Acheson Colloids*

730. Lubrication

New brochure B-3 on solid film lubrication gives results of laboratory and research tests. *Electrofilm, Inc.*

731. Machining Alloy Steels

24-page bulletin on economical combination of microstructure, tool form, cutting speed and feed for each machining operation. *International Nickel*

732. Machining Copper

32-page booklet gives cutting speeds, feeds, rakes, clearances for more than 40 copper alloys. *American Brass*

733. Master Alloys

Bulletin on custom-made alloys for remelt or reprocessing. *Cannon-Muskegon*

734. Metal Cleaning

4-page catalog 521 on degreasers. Standard and special apparatus. *Circo Equipment*

735. Metal Cutting

64-page catalog No. 29 gives prices and describes complete line of rotary files, burrs, metalworking saws and other products. *Martindale Electric*

736. Metallographic Equipment

12-page catalog E-29 describes bright-field equipment for visual observation and photography. *Bausch & Lomb*

737. Metallographic Polishing

AB Metal Digest discusses features of various models of metallographic polishing equipment. *Buehler, Ltd.*

738. Microhardness Tester

Bulletin describes the Kentron microhardness tester. *Torsion Balance Co.*

739. Microscopes

Catalog on metallograph and several models of microscopes. *United Scientific*

740. Microscopes

22-page catalog describes microscopes featuring ball bearings and rollers throughout the focusing system and a low-position fine adjustment, providing comfortable operation. *Bausch & Lomb*

741. Microscopes

8-page booklet No. 5 on research microscopes, stages, illuminators and other accessories. *American Optical*

742. Molybdenum

24-page booklet gives physical and chemical property data on molybdenum powders, wire, alloys. *Sylvania Electric*

743. Nickel Alloys

Wall chart gives engineering properties of nickel alloy wire, rod and strip. Includes Monel, Inconel, Incoloy and nickel-clad copper. *Alloy Metal Wire Co.*

744. Nickel Alloys

40-page book gives corrosion, physical and mechanical properties of Hastelloy alloys; 13 pages of fabrication data. *Haynes Stellite*

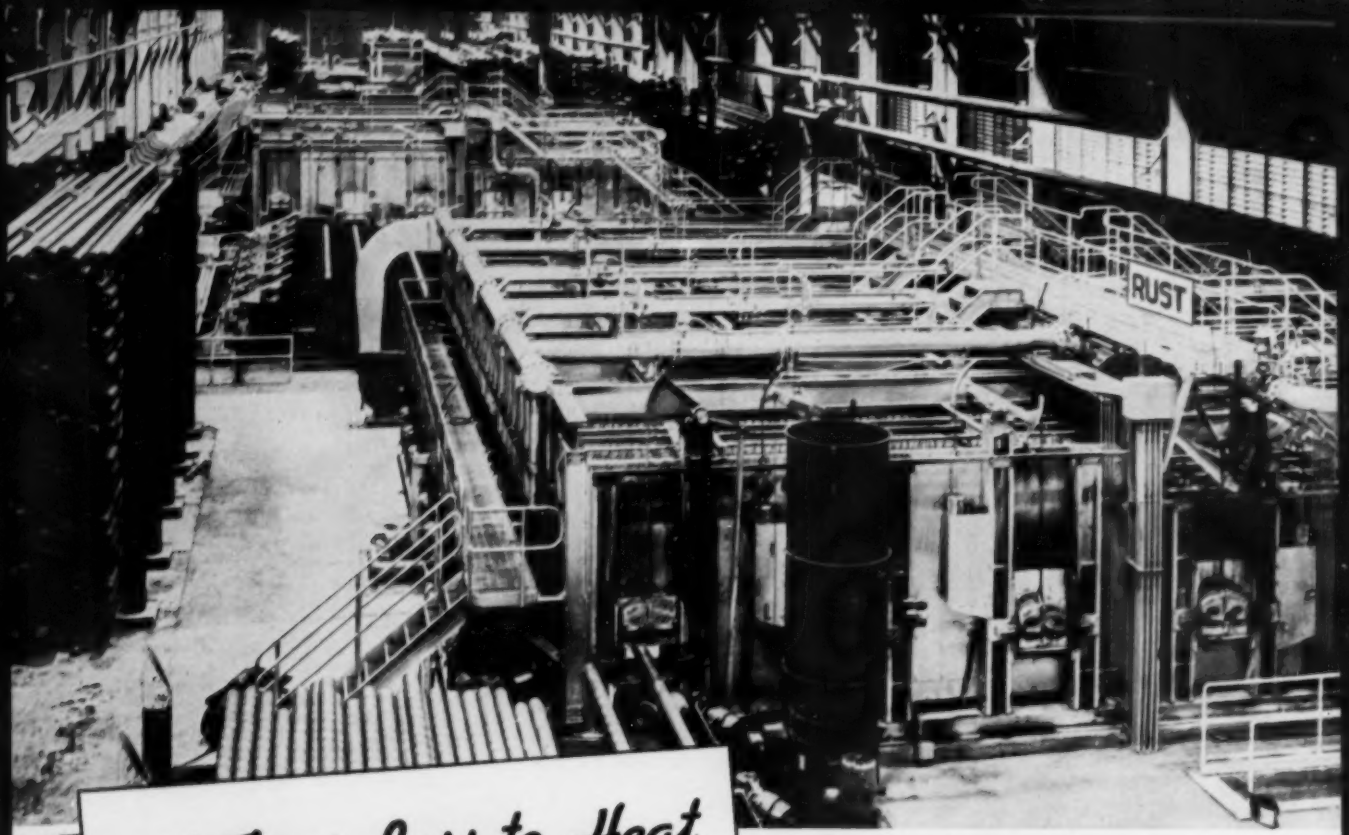
745. Nickel-Copper Alloys

28-page bulletin on alloys for heat exchangers describes typical installations of cupro-nickel or nickel-copper alloys in power plants. *International Nickel Co.*

746. Nitriding Furnace

Bulletin 646R on carburizing and nitriding furnace giving atmosphere circulation to 1850° F. *Revi Duty*

(Continued on page 32-A)



116 Tons Less to Heat in this roof

because of B&W Insulating Firebrick suspended construction

Here's another case where light weight means lower cost. The roof of this walking beam furnace is 2,320 square feet. B&W Insulating Firebrick suspended construction for a 9-inch roof weighs about 30 lbs per square foot, including the weight of rods, hangers, pipe, brick and mortar. This is approximately 100 lbs per square foot less than an arch constructed of heavy firebrick plus insulation having the same heat flow. *This saving means the B&W IFB roof is 116 tons lighter.*

The new walking beam furnace (shown in photograph above) was designed and constructed by Rust Furnace Company for Jones & Laughlin Steel Corporation. Seamless pipe is conveyed into the furnace, moves slowly from left to right on walking beam rails designed and furnished by York-Gillespie Mfg. Co., and passes out the exit door.

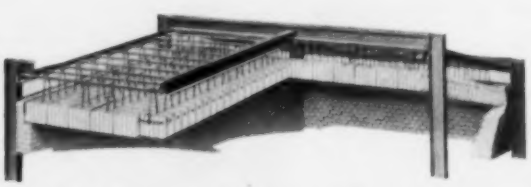
Here are the money-saving benefits of B&W suspended construction:

1. Supporting steel is less massive, far less costly. Commercial size steel can be used for roof suspension instead of special castings.

2. B&W Insulating Firebrick heat up and cool down faster. This means lower fuel costs, faster inspection.

3. Furnace temperatures can be changed quickly. When different steels call for different heating schedules, the furnace temperature can be adjusted in minutes instead of hours.

4. Installation costs are lower because these lightweight brick can be handled faster and easier than ordinary heavy firebrick.



This is a cross-sectional drawing of a typical suspended arch arrangement using B&W Insulating Firebrick. It can be used in flat or sloping roofs, nose arches and many other types of suspended furnace construction.

For complete information on B&W IFB—the *lightest* weight insulating firebrick, write to B&W today or call your local Refractories Engineer.

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REFRACTORIES DIVISION
GENERAL OFFICES: 161 EAST 42nd ST., NEW YORK 17, N.Y.
WORKS: AUGUSTA, GA.

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(Continued from page 31)

747. Nondestructive Testi
8-page bulletin on equipment fo destructive testing of bars, rods, t *Magnetic Analysis*

748. Nonferrous Forgings
34-page booklet on brass, bronz aluminum forgings. How they are composition of alloys, tolerances. *M Brass*

749. Nonferrous Melting
Bulletin 26-A on high-frequency naces for melting copper, silver, platinum, aluminum and magn *Ajax Electrothermic*

750. Nonflammable Rust Preventive
Bulletin on rust preventive com which is water soluble, nontoxic nonflammable. *Production Specialti*

751. Oil Quenching
8-page brochure tells in detail carbon steel often can replace alloy when additive is used in the quen oil. *Aldridge Industrial Oils*

752. Patterned Steel
New booklet on surface rolled pa on steel. *Sharon Steel*

753. Phosphate Coating
12-page "Phosphate Coating Che and Processes" gives data on paint ing, rust proofing, protecting friction faces, improving drawing and extr *American Chemical Paint*

754. Pickling Baskets
12-page bulletin on mechanical pic crates, baskets, chain and acces *Youngstown Welding & Eng'g*

755. Pickling Baskets
Data on baskets for degreasing, pic anodizing and plating. *Jelliff*

756. Pipe and Tubing
68-page book on pipe and tube m answering many pertinent questio tube mill operation and production gineering data and specifications.

757. Plating
4-page folder on heat exchange plating, pickling and anodizing solu *Carl Buck & Assoc.*

758. Powdered Metals
Booklet on design, properties, pr tion and application of brass and nonferrous powder parts. 24 case his *New Jersey Zinc*

759. Precision Casting
8-page bulletin on investment ca

B
No

(Continued from page 31)

747. Nondestructive Testing
8-page bulletin on equipment for nondestructive testing of bars, rods, tubing. *Magnetic Analysis*

748. Nonferrous Forgings
34-page booklet on brass, bronze and aluminum forgings. How they are made, composition of alloys, tolerances. *Mueller Brass*

749. Nonferrous Melting
Bulletin 26-A on high-frequency furnaces for melting copper, silver, gold, platinum, aluminum and magnesium. *Ajax Electrothermic*

750. Nonflammable Rust Preventive
Bulletin on rust preventive compound which is water soluble, nontoxic and nonflammable. *Production Specialties*

751. Oil Quenching
8-page brochure tells in detail how carbon steel often can replace alloy steel when additive is used in the quenching oil. *Aldridge Industrial Oils*

752. Patterned Steel
New booklet on surface rolled patterns on steel. *Sharon Steel*

753. Phosphate Coating
12-page "Phosphate Coating Chemicals and Processes" gives data on paint bonding, rust proofing, protecting friction surfaces, improving drawing and extrusion. *American Chemical Paint*

754. Pickling Baskets
12-page bulletin on mechanical picklers, crates, baskets, chain and accessories. *Youngstown Welding & Eng'g*

755. Pickling Baskets
Data on baskets for degreasing, pickling, anodizing and plating. *Jelliff*

756. Pipe and Tubing
68-page book on pipe and tube making, answering many pertinent questions on tube mill operation and production. Engineering data and specifications. *Yoder*

757. Plating
4-page folder on heat exchangers for plating, pickling and anodizing solutions. *Carl Buck & Assoc.*

758. Powdered Metals
Booklet on design, properties, production and application of brass and other nonferrous powder parts. 24 case histories. *New Jersey Zinc*

759. Precision Casting
8-page bulletin on investment castings of various ferrous and nonferrous alloys. *Engineered Precision Casting*

760. Presses
New 4-page brochure on hydraulic presses for bending, cogging, flanging, forging, forming, straightening and upsetting operations. *R. D. Wood*

761. Pressure Control
Bulletin 7040 on indicating pneumatic pressure controller. *Minneapolis-Honeywell Regulator Co.*

762. Protective Coatings
Two new catalogs on corrosion control coating for industrial construction and plant maintenance. *Amercoat Corp.*

763. Pyrometer Supplies
New edition of 56-page bulletin P1238 on thermocouples and pyrometer accessories. Engineering data on selection and installation. *Bristol Co.*

764. Quenching
New catalog on two small self-contained quenching units. *Bell & Gossett*

765. Quenching Oil
New book on mechanism of quenching, properties of quenching mediums, cooling curves. *Gulf Oil*

766. Radiography
16-page bulletin on materials and accessories for radiography. Density curves for four types of films. *X-Ray Div., Eastman Kodak*

767. Radiography
28-page booklet on products for industrial radiography gives exposure and processing data for various films used. *DuPont*

768. Rare Earths
8-page Progress Report Number 1, "Rare Earths in Iron and Steel Melting". *Molybdenum Corp.*

769. Refractories
32-page catalog on range of refractory products for steel mills, electric furnaces, melting, ladles, and other industrial uses. *Plibrico Company*

770. Refractories
12-page brochure on products for casting special refractory shapes and for gunning and troweling applications, for services to 3000° F. *Johns-Manville*

771. Roll Formed Shapes
24-page Bulletin 1053 on designing, forming and producing shapes from ferrous and nonferrous metals. *Roll Formed Products Co.*

772. Roll Forming
Bulletin 854 on roll forming of co
rolled shapes. *American Roller Die Co*

773. Salt Bath Furnaces
Data on salt bath furnaces for bat
and conveyorized work. *Upton*

774. Salt Baths
32-page bulletin on salts for temperi
annealing, neutral hardening, martempe
ing and carburizing. Heat treating da
E. F. Houghton

775. Sand Control
32-page book on defects and troubles
foundry and how to remedy through sa
control. *Claud S. Gordon Co.*

776. Saw Blades
Selector for hand or power blades te
which blade to use for various alloys a
shapes. *Henry Disston*

777. Saws
Catalog C-53 describes 35 models
metal-cutting saws. *Armstrong-Blum*

778. Shear
Bulletin on bar and billet shear
rounds, squares, flats, billets and stru
turals, either hot or cold. *Hill Acme*

779. Shell Molding
8-page technical bulletin on shell mol
ing process for stainless steel. *Coop
Alloy Foundry*

780. Silver Brazing
48-page manual on all aspects of silv
brazing applications and problems. *Am
ican Platinum Works*

781. Solvent Cleaning
16-page booklet on how to use solve
detergents for removing carbon, grea
dirt, paint. *Oakite Products*

782. Stainless Bars
28-page technical book on stainless st
bars includes processing informat
about cutting, welding, forging, upsetti
machining, and heat treating. *Alleghe
Ludlum*

783. Stainless Castings
20-page booklet shows how they
made, property and size data, typi
applications. *Crucible Steel*

784. Stainless Fastenings
20-page catalog of stainless steel
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tings and specialties. *Star Stainless Sc*

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ties, specifications, applications, design data on springs. *Alloy Metal Wire*

786. Stainless Steel
Data sheet on Type 301 gives physical properties, corrosion and oxidation resistance, mechanical properties. *Allegheny Ludlum*

787. Stamping
12-page catalog on stamping, drawing, forming and heading. *Plume & Atwood*

788. Stampings
16-page brochure on story of stamping. Handy tabular data. *Republic Steel*

789. Steel
256-page handbook lists sizes, weights, lengths, steels available, shapes. Data on mechanical properties, standard steel compositions, hardness numbers conversions. *Ryerson*

790. Steel
Bulletins on hot work steel and Type 420 stainless give forging, annealing and hardening characteristics. *Firth Sterling*

791. Steel
Bulletin on nickel-copper steel of low-alloy, high-strength type. *Youngstown Sheet and Tube*

792. Steel 52100
Data sheet on high-purity 52100 steel, made by vacuum melting. *Vacuum Metals*

793. Tanks and Linings
16 pages of data on tanks and corrosion-resistant linings for cleaning and plating solutions. *Chemical Corp.*

794. Temperature Control
Catalog G-20 on differential expansion temperature controls. Electrical and pneumatic types in ranges from sub-zero to 1800° F. *Burling Instrument Co.*

795. Testing
12-page bulletin No. 116 on proving rings for calibrating testing equipment. *Morehouse Machine*

796. Testing Equipment
8-page catalog of abrasion, physical, thickness, compression and recovery testers. *Custom Scientific Instruments*

797. Testing Machines
28-page catalog on screw power universal testing machines and accessories. Construction, specifications. *Riehle*

798. Test Specimens
Data on machine for cutting test specimens to ASTM specifications. *Sieburg Industries*

799. Textured Metal
16-page booklet on advantages and applications of textured metal. *Rigidized Metals*

800. Thermocouples
20-page Bulletin 714 on thermocouples, protecting tubes and wells, insulators, leads, connectors, heads. *Gen. Electric*

801. Thermocouples
8-page bulletin 31-H on thermocouple and extension wires, insulations, gages, calibrations, color codes. *Thermo Electric*

802. Thermostat Metals
Chart compares properties of thermostat metals produced by various manufacturers. *American Silver Co.*

803. Tin
20-page booklet describes mining of tin and its present use by American industry. *Malayan Tin Bureau*

804. Titanium Alloy
Data on ternary alloy with 3% aluminum and 5% chromium gives physical properties, forging temperatures, high temperature characteristics. *Mallory-Sharon Titanium*

805. Titanium and Zirconium
16-page bulletin, "The Hydrimet Process", on titanium and zirconium metals and hydrides, and other metallurgical hydrides. *Metal Hydrides*

806. Tool and Die Steels
28-page guide to qualities and sizes available. *Uddeholm*

807. Tool Steel Failures
124-page book, "Tool Steel Trouble Shooter", analyzes 107 tool failures and assigns causes as among tool design faults, tool steel faults, improper heat treatment, mechanical and operational factors. *Bethlehem Steel*

808. Tool Steel Guide
New 70-page brochure includes information on 50 types of tool steels and cold finishing products. *Vanadium-Alloys Steel*

809. Tool Steel Selector
Twist the dial of the 9-in. circular selector and read off the tool steel for your application. *Crucible Steel*

810. Tubing
52-page "Handbook of Seamless Steel Tubing". 26 pages of data. *Timken*

811. Ultra Strength Steel
Results of three year research and test program evaluating properties of Type 4340 steel for aircraft structures. *International Nickel*

812. Ultrasonic Cleaning
Folder on Sonogen ultrasonic generator for metal cleaning. *Branson*

813. Ultrasonic Testing
Data folder describes instruments using ultrasonics for various tests—immerscope, "B" scan and flaw recorder. *Curtiss-Wright*

814. Ultrasonics
Bulletin GEA-6239 on ultrasonic power generators for industrial cleaning equipment. *General Electric*

815. Vacuum Coating
Bulletin on principles, production steps, applications, equipment. *National Research*

816. Vacuum Melting
8-page bulletin on production and testing equipment for vacuum melting. Advantage. *Utica Metals Div., Utica Drop Forge & Tool*

817. Vacuum Pumps
Bulletin 401 on bellows-type valves for vacuum pumps. *Kinney Mfg. Div.*

818. Vanadium in Steel
189-page book on properties of ferrous alloys containing vanadium and their applications. *Vanadium Corp.*

819. Welding
Data card 155A tabulates arc welding procedures for various types of tubing. *Babcock & Wilcox.*

820. Welding Electrode
Bulletin No. 5 on the development of an electrode for metal arc welding of wrought 35 Ni-15 Cr-1.25 Si alloy. *Rolled Alloys*

821. Welding Electrodes
Report No. W5410 on low hydrogen electrodes for high alloy steels. *Harnischfeger Corp.*

822. Welding Equipment
Catalog on Cadweld process and arc-welding accessories. *Erico Products*

823. Welding Rods
New bulletin on processing of welding rod materials, master alloys and other specialized products. *Shieldalloy*

824. Wire Belts
Folder gives flow diagrams for continuous heat treating showing uses of wire belts. *Cambridge Wire Cloth Co.*

825. Wire Belts
16-page booklet on selection of standard steel conveyor belts. Installation. *Wickwire Spencer Steel*

MARCH, 1956

569	594	619	644	669	694	719	744	769	794	819
570	595	620	645	670	695	720	745	770	795	820
571	596	621	646	671	696	721	746	771	796	821
572	597	622	647	672	697	722	747	772	797	822
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574	599	624	649	674	699	724	749	774	799	824
575	600	625	650	675	700	725	750	775	800	825
576	601	626	651	676	701	726	751	776	801	
577	602	627	652	677	702	727	752	777	802	
578	603	628	653	678	703	728	753	778	803	
579	604	629	654	679	704	729	754	779	804	
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581	606	631	656	681	706	731	756	781	806	
582	607	632	657	682	707	732	757	782	807	
583	608	633	658	683	708	733	758	783	808	
584	609	634	659	684	709	734	759	784	809	
585	610	635	660	685	710	735	760	785	810	
586	611	636	661	686	711	736	761	786	811	
587	612	637	662	687	712	737	762	787	812	
588	613	638	663	688	713	738	763	788	813	
589	614	639	664	689	714	739	764	789	814	
590	615	640	665	690	715	740	765	790	815	
591	616	641	666	691	716	741	766	791	816	
592	617	642	667	692	717	742	767	792	817	
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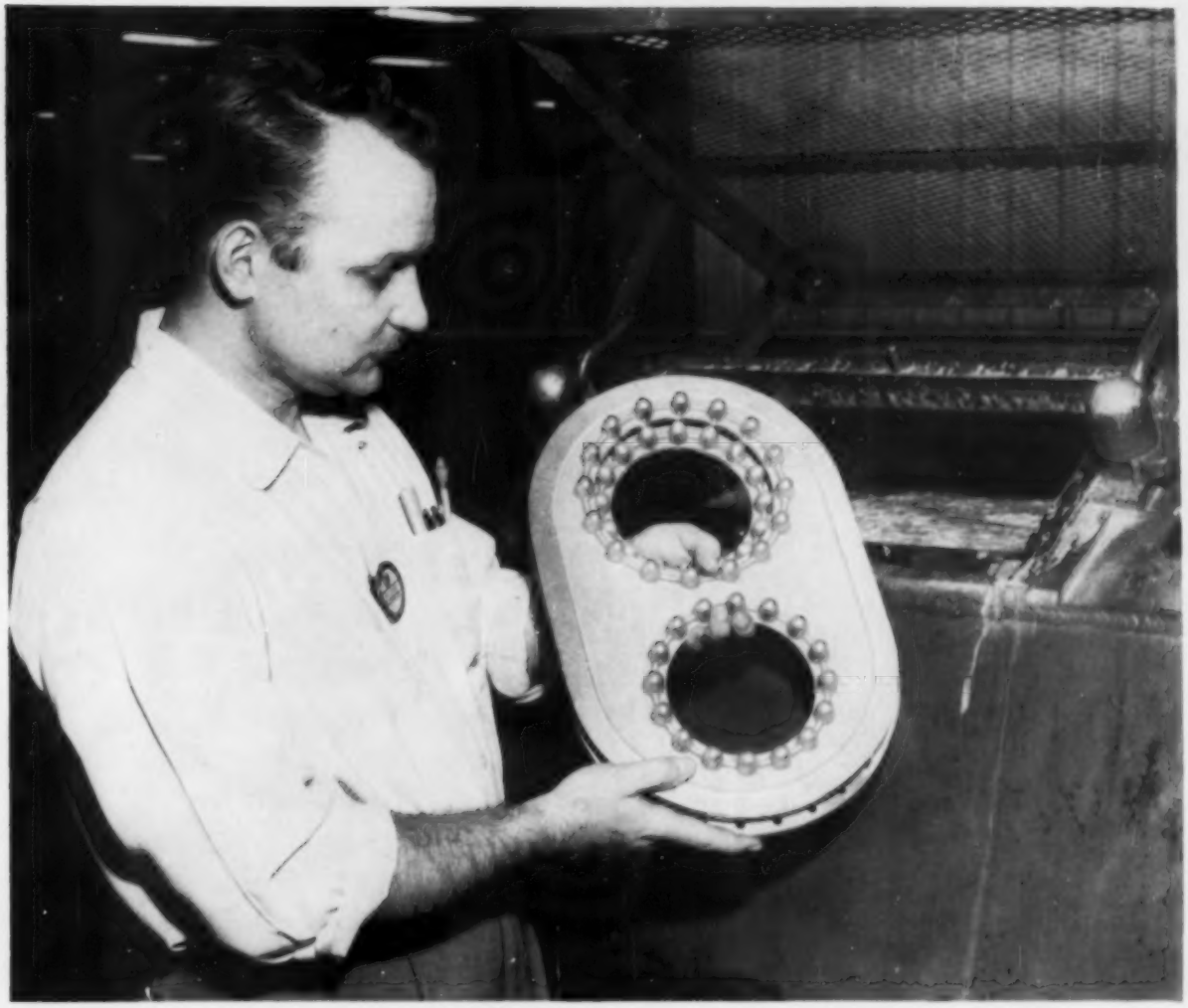

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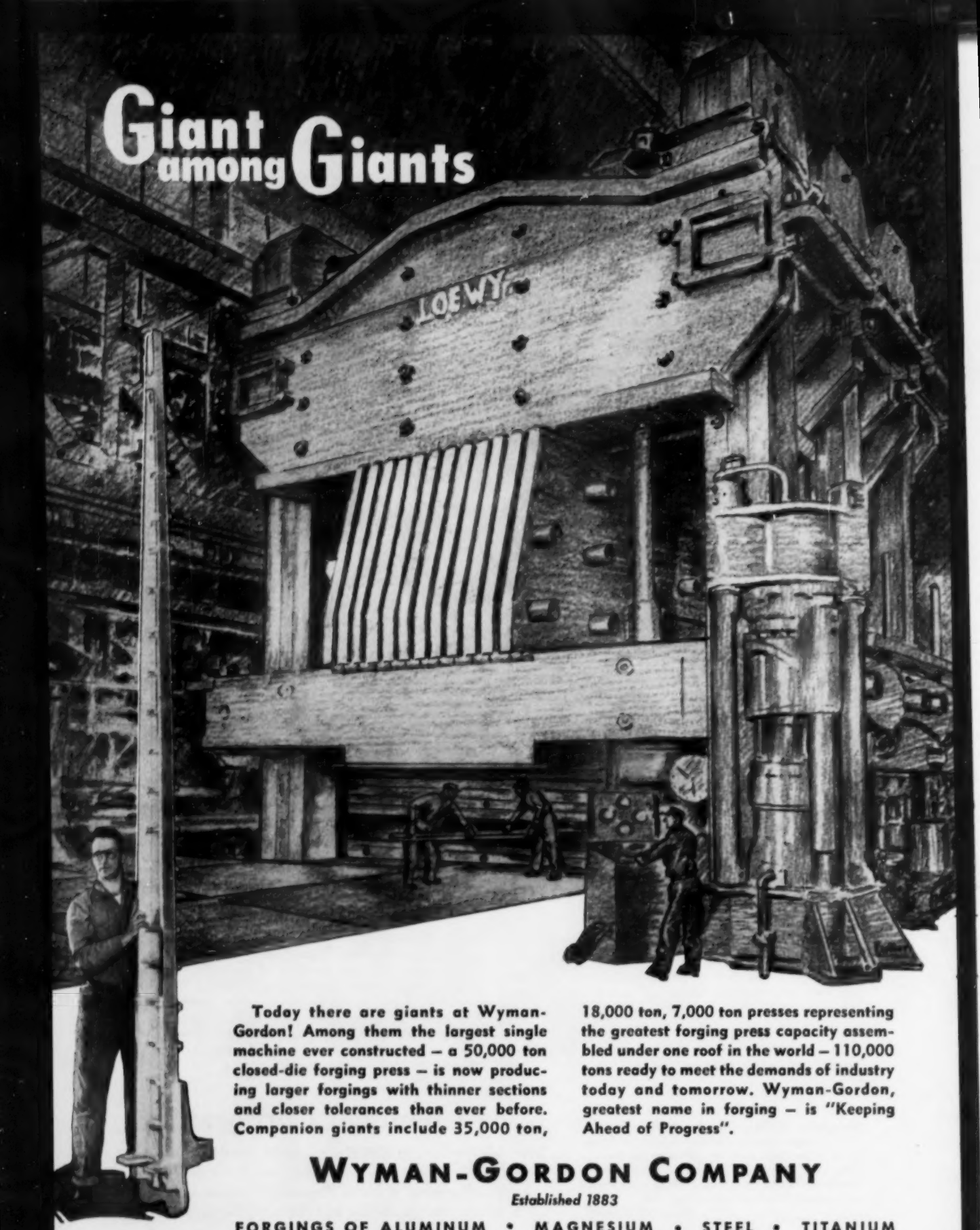

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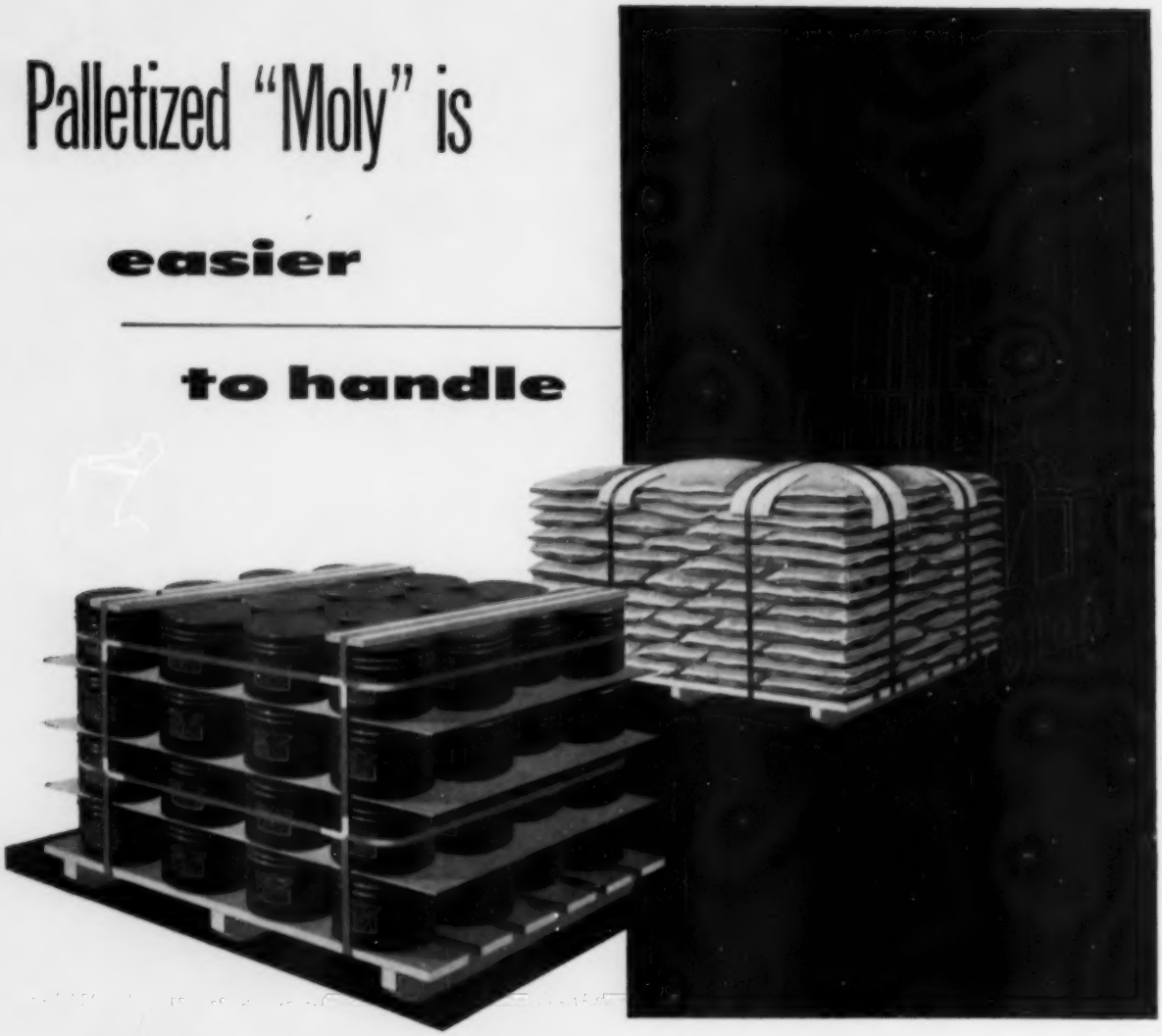

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temperature control...

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LOOKING for versatile, dependable, economical control? Then choose from the line of Brown millivoltmeter controllers. This varied family of instruments fills the requirements of hundreds of temperature control applications where a chart record is not essential. On ovens, dryers, furnaces, plating tanks, plastic presses and other heat-using equipment, they bring sensitive, reliable control within the reach of any budget.

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Our Technical Service Department works round the clock when necessary to set up a process and keep it working effectively with minimum interruption in production.

Time is no factor when ACP technical service men move into your plant. They stick with the job until it's done. They not only furnish assistance in installing the system, but also instruct plant personnel in its operation. Then, to keep the process working effectively with a minimum of production slowdowns, they establish a schedule of periodic inspection, if you so desire. This permits ACP to check the operation of process and equipment, to analyze procedures, to suggest changes as needed to maintain uniform results.

This policy of service to its customers is not a new one with ACP—it has been going on for more than 40 years. And it doesn't stop with service in your plant. Our Engineering Department will design the equipment, our Pilot Plant will develop the process sequence, and our Quality Control Laboratories will maintain a continuing check on the processed metals. Write for complete information about ACP.

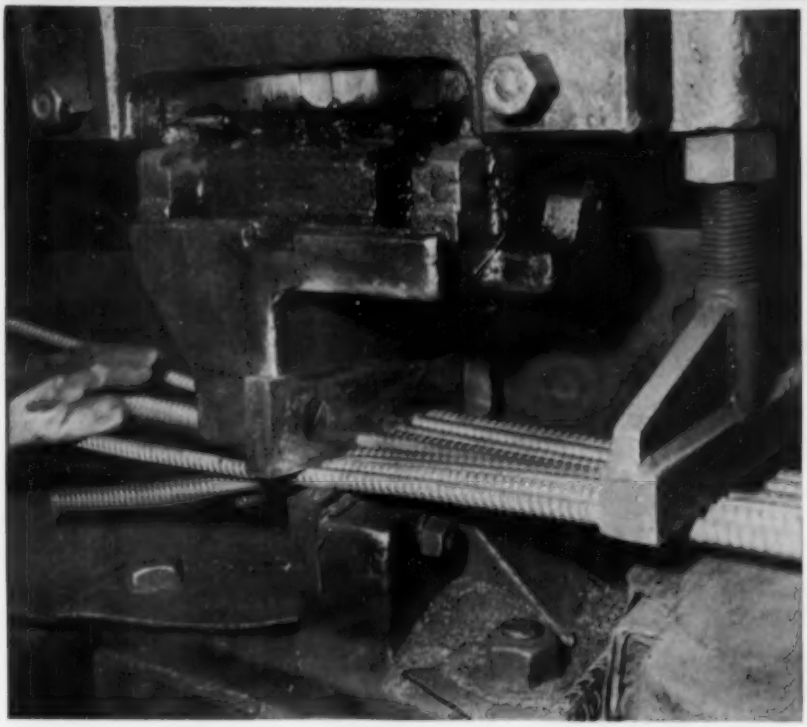
AMERICAN CHEMICAL PAINT COMPANY, Ambler 16, Pa.

DETROIT, MICHIGAN NILES, CALIFORNIA WINDSOR, ONTARIO

CHEMICALS ACP PROCESSES

Tool Steel Topics

BETHLEHEM STEEL



Shear Blades Last Twice As Long When Fabricator Changes to Bearcat

For many months a Midwestern fabricator had been using shear blades made of an alloy tool steel. The blades were used in cutting steel reinforcing bars and joists. Production was fairly good, too, as each blade sheared approximately 400 tons of material per side before being redressed.

Then he decided to try, in the same operation, a blade made of Bethlehem Bearcat tool steel. The blade, hardened to Rockwell C-59, was put to work shearing both ¼ in.-x-4 in. plate steel, and reinforcing bars ranging in diameter from ⅜ in. to 1¼ in. The advantage of longer wear and greater economy was soon apparent, for the new blade handled more than 830 tons of material per side —more than twice the tonnage which had been sheared by the former blade.

Bearcat is a tough, general-purpose air-hardening tool steel. It has superior resistance to wear, and is also exceptionally resistant to shock. Bearcat has an air-hardening characteristic, which minimizes quenching hazards and also provides good resistance to distortion in heat-treatment.

In addition to shear blades, Bearcat tool steel can be used economically for such varied items as chisels, punches, gripper dies, rivet sets, hot headers, master hobs and die-casting die inserts.

Why not put in an order for a trial piece of Bearcat today, while you have it in mind? You can't lose by giving it a workout. All you need do is get in touch with your Bethlehem tool steel distributor. He's as near as your telephone. Or order direct from our mill depot.

BETHLEHEM TOOL STEEL ENGINEER SAYS:

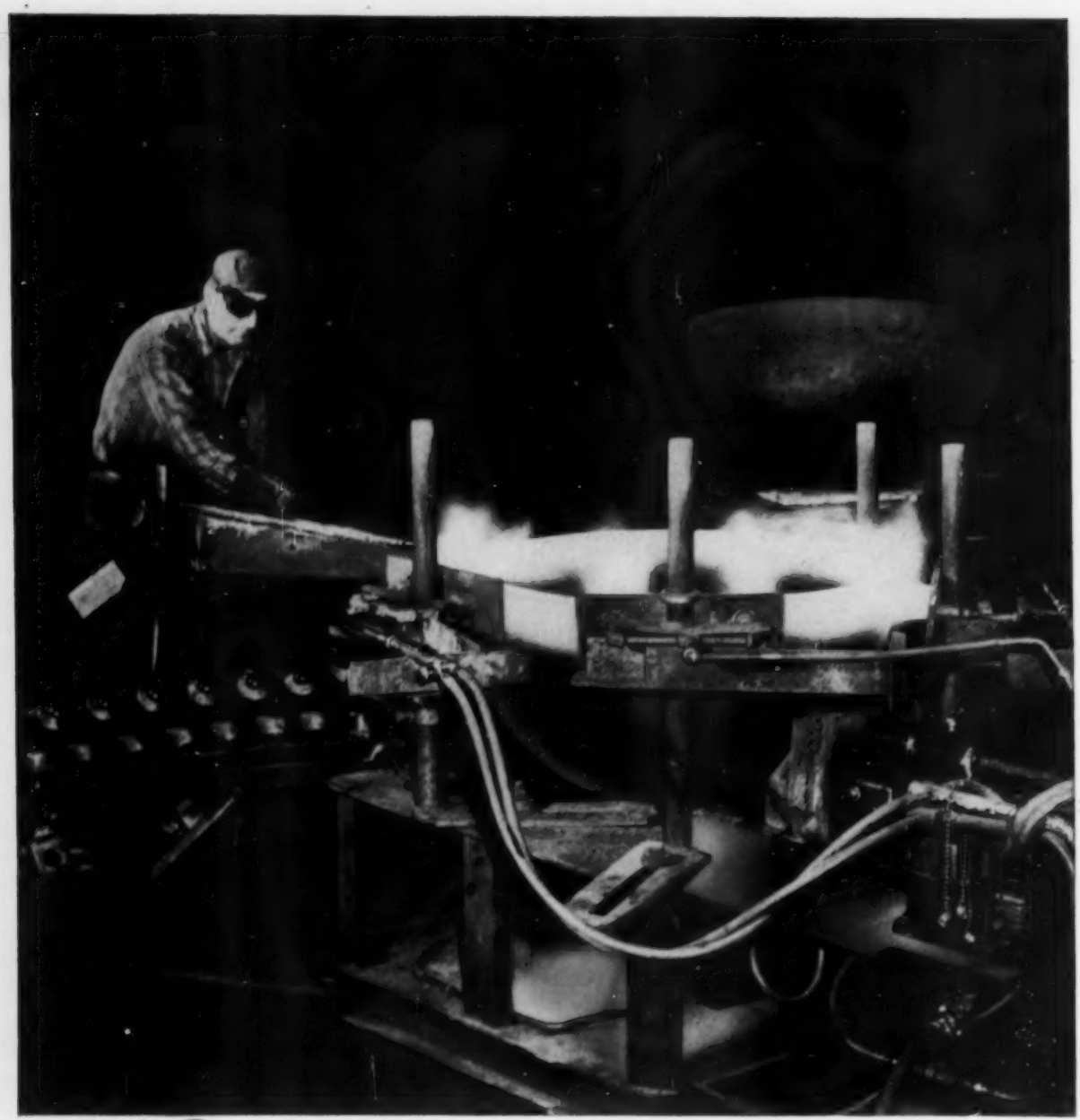
Blind Holes Are Dangerous

Without proper care, blind holes can be troublesome in the heat-treatment of tools. Typical of blind holes which usually get little attention are holes for studs or dowel pins. The exposure of blind holes to liquid-quenching produces extremely high internal stresses, with the possibility of cracking the tool during heat-treatment, or in service.

If it is not required that blind holes be hard internally, trouble can be avoided by packing the holes, prior to quenching, with clay, asbestos rope, steel wool, or a steel plug. Blind holes are particularly objectionable if they are required to be uniformly hard on the inside surface. This requirement can be met consistently only by using air-hardening steels.

"Teamwork" is the title of a 16-mm color film, with sound, recently released by Bethlehem. The film describes the manufacture of Bethlehem tool steel, and explains its quality-control and heat-treatment. Typical applications of carbon, oil- and air-hardening, shock-resisting, hot-work, and high-speed grades are included.

Prints of this 30-minute film are available for showing to distributors, heat-treaters, die-makers, machinists and machine-tool manufacturers, as well as to technical societies and engineering students. If you would like to see the picture, just write to Publications Department, Bethlehem Steel Company, Bethlehem, Pa. It would be well to select a showing date as far in advance as possible.

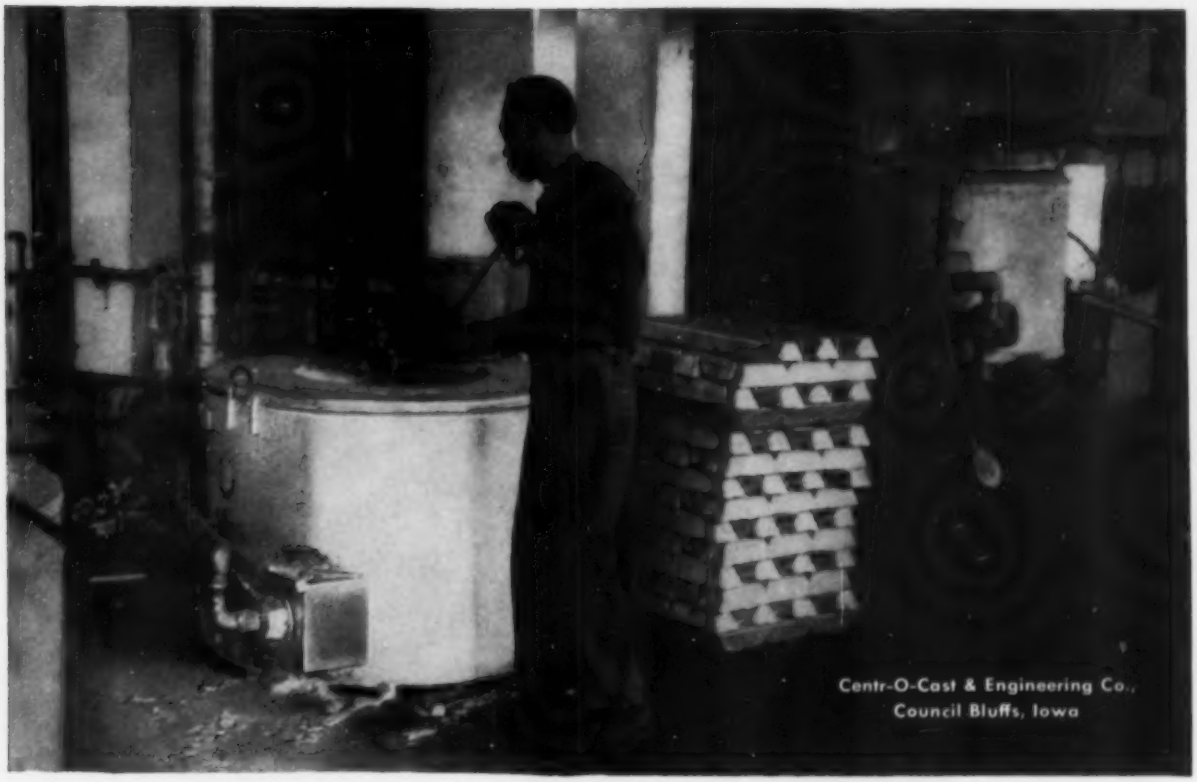


GAS gives new strength to tank heads at Lukens Steel Company

Lukens Steel Company, Coatesville, Pennsylvania, makes a complete line of heads for high pressure LP-Gas storage tanks. For economy reasons, these heads are cold pressed. But cold pressing leaves brittle areas on the head rim. When heads go through the "bumps" and "bangs" of tank assembly, breaks occasionally develop in the brittle area around the head rim.

Lukens solved the problem by stress relieving the heads with Gas. An assembly line conveyor brings the heads to a special Gas-fired machine where a battery of burners stress relieves the entire periphery of the ¼ inch thick head rim. As a result, there are no more brittle areas in the rim. And there are no more breaks during assembly operations.

When you have a problem in your production line involving heat processing, call your Gas Company Industrial Specialist. He'll be glad to discuss the economies and results you can expect from using Gas and modern Gas-fired equipment. *American Gas Association.*



Centr-O-Cast & Engineering Co.,
Council Bluffs, Iowa

"Cities Service Heat Prover Showed Why Holding Pots Burned Out Prematurely!"

Put yourself in the place of Centr-O-Cast & Engineering Company.

You make permanent mold and centrifugal aluminum castings from 2 ounces to 65 pounds . . . and your products are so wanted that you've increased your business 50-fold since you began 10 years ago.

To meet this demand, you're now operating at a melting capacity of 1,500,000 pounds of aluminum per month, using 20 holding furnaces, two 500# melting furnaces, and two 800# melting furnaces.

Then suddenly—TROUBLE! One after another, holding pots start burning out prematurely . . . and you've got to find the reason and the solution *fast*.

How? Centr-O-Cast solved the problem by calling in their local Cities Service Lubrication Engineer—the man with the ingenious little troubleshooter known as the Cities Service Heat Prover.

Enabling simultaneous readings of oxygen and combustibles, the portable Heat Prover quickly determined excessive heat as the cause of the burnout and revealed what combustion adjustments were necessary. "Since then, there's never been a premature burnout due to improper combustion," says partner L. W. Wickson. "What's more—Cities Service has supplied this service free!"

Nothing can be added to Mr. Wickson's statement except an invitation to you to try the Cities Service Heat Prover in solving your combustion problems. Talk with your Cities Service Lubrication Engineer or write Cities Service Oil Company, Sixty Wall Tower, New York 5, N. Y.

It Turned the Heat on a Burning Problem. The Cities Service Heat Prover was used by a Cities Service Lubrication Engineer to solve a costly problem of preliminary burnout in holding furnaces. Heat Prover showed cause and enabled necessary combustion adjustments.

Getting the Finishing Touch, castings of the Centr-O-Cast & Engineering Co. are smoothed off on grinding wheel. Principal markets are automotive, electrical and farm fields—whose heavy demand boomed Centr-O-Cast's sales to 50 times its 1946 volume.

CITIES SERVICE

QUALITY PETROLEUM PRODUCTS

Like to join this session on atomic-powered ships?

This is a working session of some of the country's best scientific and engineering minds. Their assignment: develop, design and construct atomic power plants for a fleet of ships. Where are they? At Bettis Plant, Pittsburgh, operated by Westinghouse for the AEC. This is the largest design and engineering center for atomic power plants in the country. Here the power plants for an atomic fleet are actually being designed and built.

You can join them if you are a competent metallurgist. The work is fascinating—anything but routine—because so many of the important things being done at Bettis are being done for the first time.

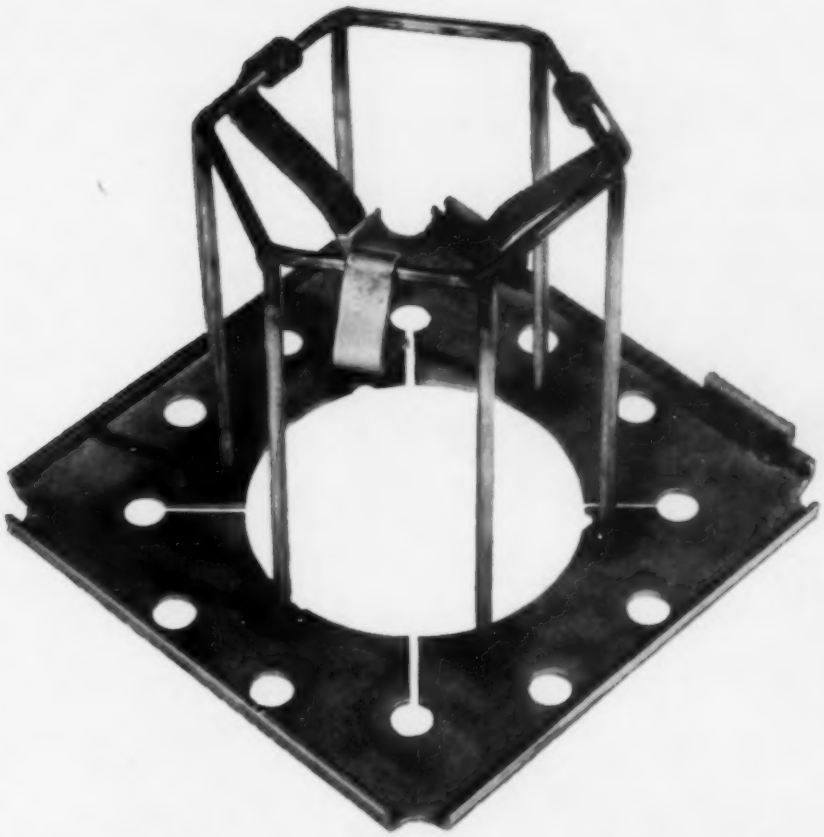
Activity at Bettis Plant is expanding because more power reactors are being built here than at any other place.

Atomic experience is *not* required. Write for a descriptive brochure describing opportunities in your field. Be sure to indicate your specific interests. Mr. A. M. Johnston, Westinghouse Bettis Plant, P. O. Box 1468, Dept. A-17, Pittsburgh 30, Pa.

Westinghouse

BETTIS PLANT

First in atomic power



Still in Use after 1½ Years

of Heating and Quenching

This tray, made of a HAYNES high-temperature alloy, has been subjected to continual heating and cooling for 18 months . . . and it is still in good shape.

In the heat-treating operation, trays and rings are heated to 1550 deg. F for a half hour and then given a rapid oil quench. This repeated exposure to high temperatures and thermal shock caused other trays to twist out of shape in a few days.

The HAYNES alloy used to solve this problem was HASTELLOY alloy C. There are 10 other HAYNES high-temperature alloys—each designed to resist certain severe operating conditions. All of the alloys have remarkable strength at high temperatures, coupled with excellent oxidation resistance and dimensional stability. One of them may be the answer to a production or maintenance problem in your plant.

For information on prices, available forms, and properties of these alloys, write to our general sales office in Kokomo, Indiana or to any of the District Sales Offices listed below.

HAYNES TRADE-MARK ALLOYS

HAYNES STELLITE COMPANY

A Division of Union Carbide and Carbon Corporation

UCC

General Offices and Works, Kokomo, Indiana

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what's new

IN STAINLESS STEEL FROM STOCK

Extra-Large Plates & Sheets— You can save on welding costs and improve the appearance of big fabricated pieces now that you can get stainless plates and sheets from Ryerson stocks in extra-large sizes. Types on hand: *Plates*—304, 304L, 315 and 316L in 96″ widths up to an inch thick, and 80″ widths even heavier. *Sheets*—304, size 72″ x 144″, in 10, 11, 12, 14 and 16 gauges.

Aircraft Steels Specs: Just off the press, a new booklet on aircraft quality stainless and alloy steel containing latest information on Aeronautical Specifications (Military (MILO, Air Force-Navy (AN), Federal (QQ-S) and AMS). Also included: a complete listing of aircraft quality stainless and alloy steels available for quick shipment from Ryerson. To get your copy, write your nearest Ryerson plant or Box 8000-A, Chicago 80, for Booklet 103.

Stainless Pipe for Welding Applications: Now there's no need to wait for mill deliveries or to use expensive stabilized types when you want stainless pipe suitable for welding. Type 304L pipe, an extra low carbon type that eliminates the need for stress relieving after welding, has recently been added to Ryerson stocks. Size range: Schedule 40 welded pipe in commonly used sizes from ¼″ through 2″. Schedule 40 seamless in 3″, 4″ and 6″ pipe sizes.

Save 7¼¢ Per Pound! For mild corrosion applications, type 430 straight-chrome stainless often serves quite as well as nickel-bearing types—and you save 7¼¢ per pound! Ryerson stocks include Type 430 sheets in many gauges and sizes. Technical data on request.

Easy-to-Weld Plates and Sheets, Too! Both stainless sheets and plates in Type 304L and Type 316L have recently been added to Ryerson stocks. In applications involving welding and stress relieving, where carbide precipitation may occur, these extra-low-carbon steels can often replace expensive stabilized types.

Save 30% on Ornamental Tubing! Recently added to Ryerson stocks, Type 302 ornamental stainless tubing is priced substantially below comparable stainless tubing for other than ornamental purposes. Yet it is more than satisfactory for many applications such as in restaurant and hospital equipment.

Joseph T. Ryerson & Son, Inc.

EVERY TYPE, SHAPE AND SIZE

Whether you need a single piece of stainless or a truckload draw on Ryerson stocks of more than 2200 sizes, shapes, types and finishes.

RYERSON STEEL

In stock: Carbon, alloy and stainless steel... bars, structurals, plates, sheets, tubing, reinforcing bars, machinery & tools, etc.

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Metal Progress
Volume 69, No. 3 March 1956

Light Metal in Our Two-Ton Autos?

At the general meeting of the Society of Automotive Engineers in Detroit, the Aluminum Co. of America held a well-organized conference to transmit to the press the good news that considerably more of its favorite metal (now dubbed "The Metal With a Thousand Faces") will be used in passenger cars in 1956 than in previous years. During that same week there was an opportunity for the Editor to talk with good friends at Ford, G. M., and Chrysler, and get a view of the 1001st face, so to speak.

As little as 13 lb. of aluminum is used in a 1956 standard Chevrolet; the other extreme is 191.5 lb. in the Cadillac "Eldorado". On the average only 35 lb. per car, but when multiplied by seven million cars the result is close to 125,000 tons of aluminum! It's another instance of the Scottish proverb, "Many a mickle makes a muckle."

The aluminum industry, like most of the others in nonferrous production, is fond of measuring weights in pounds rather than tons, but no matter how you say it, 125,000 tons or the bigger-sounding 250 million pounds, it's still 7.5% of the American production of primary ingot in 1955. It also amounts to nearly as much as goes into aircraft, where aluminum still reigns supreme over steel, magnesium and titanium. So it's really big business.

Maybe the reader who has come this far will be curious – as was the Editor – to know where this aluminum is hid in the Plymouth he drives from home to work. One third of all the aluminum used in the entire American automobile industry now goes into engine pistons. Aluminum pistons have been all-but-universal for many years; pistons cast in permanent molds are cheap and accurate; a considerable amount of second-

ary metal can be absorbed; the piece is light and has small inertia in its reciprocations; its high thermal conductivity also helps. This use is steady, and its volume depends directly on number of cars being manufactured.*

One important reason for the recent upswing in aluminum consumption is the automatic transmission. It takes from 15 to 25 lb. of castings for the housings and other parts which transmit the fluid power. As the proportionate number of new cars so equipped is increasing, the amount of aluminum will of course go up correspondingly. It is used here in place of iron primarily because an accurately finished casting is cheaper. This simple fact will reappear later in this essay.

Pistons and automatic transmissions thus account for 60% of the aluminum now going into automobiles. All the rest, indeed, comes from bits and pieces. Power steering and power brakes use many aluminum parts. One reason is that relatively few cars now have those extras built into them, and it is easy to tool up for production on permanent mold aluminum parts.† It might be suspected, in fact, that when these devices become standard equipment and the volume of production leaps up, steel and iron may be introduced into some of the easy parts.

One field where the Alcoa men were very hopeful is for the replacement of more expensive and scarcer copper. For example, aluminum battery cables can be made cheaper than copper ones, now that some problems concerning joints into terminals and some difficult corrosion troubles are being solved. Here high electrical conductivity is a prime necessity. High heat conductivity also points to the radiator – another interesting possibility which has been studied for so long one automobile friend remarked, "If the aluminum people had made several thousand such radiators and installed them on their employees' cars all over the country five years ago, we wouldn't be talking about it now – either the idea would have been forgotten or we would be using nothing else."

However that may be, a radiator of copper tubing with aluminum fins brazed on will probably appear on one of the 1957 models, and the Alcoa men think that production and corrosion problems are so well in hand that the all-aluminum radiator will be standard equipment within five years. The present automobile front-end radiator takes about 21 lb. of copper on the average; an all-aluminum one would weigh 13 lb. "It will be cheaper than the present copper one" – a statement which, if true, will be compelling.

Light weight, strength, good heat conductivity and attractive finish should be a good reason for using forged aluminum wheels and brake drums (all of this is "un-sprung" weight which should be minimized) but so far only the deluxe Cadillac has adopted them. (Think of gilded spokes and white-walled tyres!) More poundage of anodized and dyed or pigmented sheet is actually being used in radiator grills, although the entire consumption for trim now amounts to only 7% of the aluminum bought by the automobile industry. However, the producers hope that eye appeal will cause the body designers to use a lot of it for interior trim. The variation in surface texture and color is almost unlimited, the sheet has good formability, it is cheap and durable, and fully integrated production lines are now in existence. Whereas aluminum cannot be plated nearly as readily as steel, the situation is reversed when it comes to coloring. This holds also for extrusions for door and window frames (interior).

As to exterior trim, prospects are looking up. Considerable experience, especially in European cars, gave aluminum a tarnished eye – not only from weathering effects but from damaging effects of electrolytic couples set up by moisture trapped in joints wherein the aluminum is on the sacrificial end and gradually disappears. However, the anodized surface is apparently a permanent electrical insulator at such contacts. It also has other virtues, such as protecting the natural metallic luster from tarnishing and as an excellent mordant for colors. The first advantage is responsible for the use of bright aluminum exterior trim on the new Volkswagen (and our own Greyhound busses) and the second for bright radiator grills on some expensive American models. (Similar considerations indicate that die-cast zinc hardware such as door handles are fairly secure in their present domain; even though the metal in the piece may cost a bit more, it can be easily polished and plated and any induced corrosion is on the steel side of the couple.) As to the all-aluminum body – forget it. The only thing even the Alcoa men have any hopes for is a brightly colored aluminum roof for a flashy hard-top suited for play-boys. When sufficient wide aluminum sheet becomes available, doors, trunk covers and engine hoods – now all too heavy – can be examined.

*The six-cylinder engines are sprouting a new pair, and the application seems assured until the gas-turbined car of the jet age arrives.

†For this same reason a considerable proportion of an automobile air conditioner is made of aluminum.

Finally we come to the real possibility which might boost today's consumption per car of 35 lb. many times, even though the figure may not reach the 300 lb. the producers are understandably shooting at. That is for intricate castings now made of gray iron. At the Alcoa conference a good deal was said about the revival of interest in cylinder heads, where the heat conductivity and castability of aluminum are needed. A lot of unfavorable experience has accumulated with such castings in the United States, some due to antifreeze and radiator cleansing dopes (aluminum does not resist corrosion by *every* solution) but more due to *contact* corrosion with iron cylinder blocks or steel bolts. Aluminum men say the first has been licked by correct alloy formulation and heat treatment, and the second can be avoided by proper gaskets and insulation – although one cannot be so hopeful that the garage mechanic will follow the rules.

A much better case in point is the Chrysler converter housing, now in production. The old iron casting as received from the foundry weighs five times as much as the aluminum one (which costs four times as much per pound). Furthermore the aluminum die casting is much closer to shape and the amount of machining is down sharply.

Automobile metallurgists are understandably much interested in these possibilities. Cost studies frequently show little to be gained by a substitution; cost of appropriate changes in existing foundry or machining lines or a minor change in cost per pound of ingot metal may throw the balance over toward existing practices. However, substitution is strictly in the cards when planning new capacity. Witness the recent contract between Ford and Reynolds Metals Co. whereby the latter will expand its Alabama plant and deliver molten metal direct to a new Ford foundry alongside. Amounts contemplated are 64,000,000 lb. per year. That just about doubles the entire consumption for all purposes of all 1955 Ford, Mercury and Lincoln cars, and is one quarter of the present consumption of the entire industry. The scheme also follows a pilot operation in 1949, when Reynolds furnished molten aluminum from its reduction plant in Arkansas to a small adjoining foundry to make Buick dynaflow transmission parts.

So aluminum is on its way. There is one sobering thought, though. Cast magnesium can do much the same as cast aluminum in many, many places where gray iron is now serving. If one of the automobile Big Three should hook up with the magnesium boys to the extent of 50 to 100 million pounds a year, think what that would do for the price of that even-lighter metal!

A Mere Youngster Salutes Its Elder

The Engineer, that admirable British weekly, was founded 100 years ago, and celebrates the event fittingly with a handsomely printed issue, containing 30 articles discussing the mutual influences of engineering and various aspects of current life, thought and government. Heartiest congratulations from *Metal Progress* – a mere 25-year-old!

The Engineer's ambition at the outset (an ambition thoroughly well achieved, let us hasten to say) was to be a technical newspaper for all engineers. "Engineers" meant military engineers skilled in building fortifications, civil engineers who built roads, bridges and water works, marine architects, and mechanical engineers. A century ago the stationary steam engine was well advanced, although the Corliss engine with its efficient valves was just being made. The situation as to other prime movers may be imagined from the fact that Otto was 24 years old, Parsons was 18 months and Diesel not yet born. While electric telegraphs existed, electrical *engineering* awaited such men as Westinghouse and Edison, then both 9 years old. Metallic materials of construction were much the same as those available to Leonardo da Vinci. True, Bessemer, Siemens and John Fritz were in middle age, but their revolutionary work which gave the world a massive steel industry was still to be done. The principal example of mass production in 1865 was the manufacture of interchangeable parts for the Colt revolver.

Such a field would appear to us to be fairly narrow but doubtless the founders of the weekly journal did not think so. However that may be, *The Engineer* has kept expanding its editorial field as the field of engineering has expanded, and now one wonders where is the limit. Almost as remarkable it is that the editorial chair has been occupied for 91 of these 100 years by only three men, father, son and grandson: Vaughan Pendred from 1865 to 1905, Loughman Pendred from 1905 to 1946, and Benjamin Pendred from 1946 to date.

Let us wish the present editor another three decades of successful work, matching the performance of his distinguished forebears!

Experimental Blocks and Turbine Blades With Tiny Cooling Passages

Powder Metallurgy Permits Air Cooling of Turbine Blades

*By R. W. A. BUSWELL, I. JENKINS and E. R. PERRY**

A practical solution to operating engines with gas at over 2000° F. has been developed in Britain. Matrices of many tiny cooling passages are formed in metallic blades and vanes by volatile cores properly placed in powder metal pressings.
(H general, T 25, SG-h, Co)

Much effort has been put, both here and in other countries, on materials which are suitable for use in gas turbines. They have to withstand the severe operating requirements of high mechanical strength as well as resistance to creep, thermal shock, fatigue and oxidation. The best alloys available are still unsatisfactory for temperatures much in excess of 900° C. (1650° F.)† However, the effect of temperature on performance is considerable, and in a project in which The Research Laboratories of The General Electric Co., Ltd., of England were associated‡ it was desired to investigate the effects of operating a turbine at gas temperatures of 1200°

*Research Laboratories, General Electric Co., Limited, Wembley, England.

†The American situation is well stated in the article by V. N. Krivobok and E. N. Skinner, "Stainless and Heat Resistant Alloys", in *Metal Progress*, September 1955.

‡See Buswell, Pitkin and Jenkins' contribution to the symposium on high-temperature steels and alloys for gas turbines in the Iron and Steel Institute's Special Report No. 43, 1951, p. 258; also Buswell, Reeman and Ainley, "An Experimental Single-Stage Air-Cooled Turbine", in the *Proceedings* of the Institution of Mechanical Engineers (London) Vol. A167, 1953, p. 341 to 370; also Jenkins and Perry, "Sintered Cobalt-Based Alloy for Gas Turbine Blading", Second Plansee Seminar on Powder Metallurgy, Reutte, Austria, June 1955.

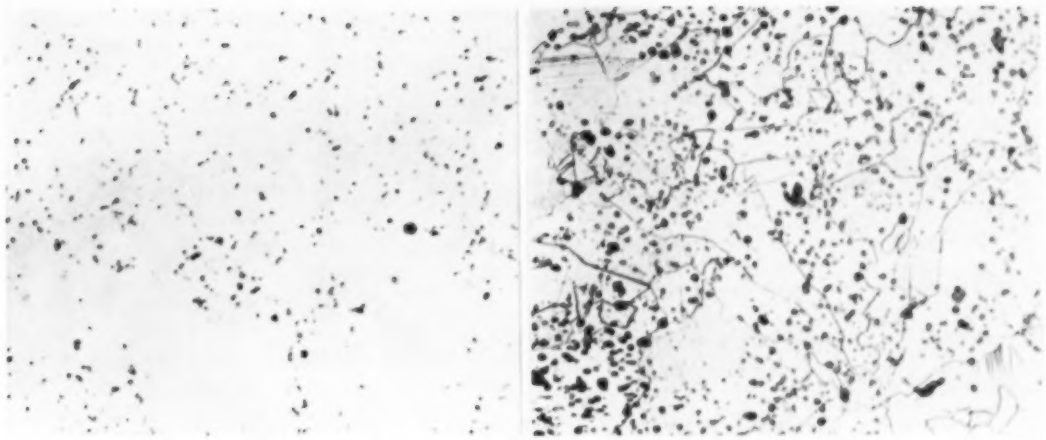


Fig. 1 – Sintered Alloy, Before and After Etching. 200 ×. Both polished mechanically, finishing with <1μ diamond dust. Right was etched in 3 parts concentrated HCl and 1 part (100 vol.) H_2O_2

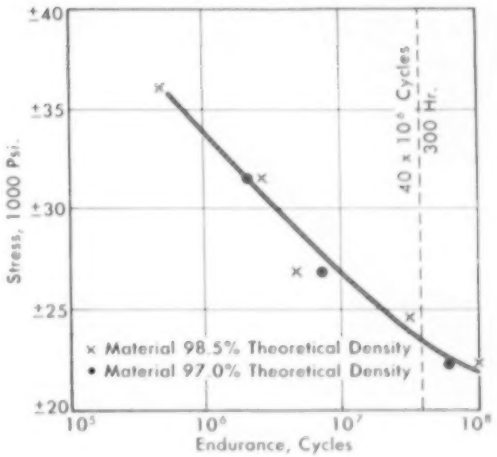


Fig. 2 – Results of Fatigue Tests at 750° C. (1380° F.) in Haigh Machine

C. (2200° F.) under actual running conditions. Hottest parts of this turbine, including blades and nozzles, were to be air cooled to insure that the stress requirements were within the capabilities of existing materials.

One of the most difficult problems present in this project was the manufacture of the rotor blades and nozzle guide vanes. Effective cooling required internal passages of large surface area, such as a multiplicity of small holes running the full length of the blade. Although methods of fabrication providing for cooling passages of large surface area had been developed, the design requirement of the equivalent of 38 holes of 0.030-in. diameter for 1-in. chord blades, and 53 holes of 0.040-in. diameter for 2.25-in. nozzles, called for a considerable advance in technique; drilling was out of the question on account of the high ratio of length to diameter of the holes. In view of this, powder metallurgy was considered, since this approach also offered the advantage of pressing components to shape.

The method proposed (now covered by British Patent No. 611466) was to incorporate cadmium wires in a pressing and to evaporate off the cadmium at a low temperature, leaving a compact ready for sintering with holes suitably disposed. These holes prevented any hot or cold work to improve the properties, and the sintered material, therefore, had to have the minimum design properties, and a search was started for a material which would comply with the designers' demands.

Table I – Specifications for Powders

	Rhokana Cobalt	Tungsten	50-50 Cr-Co Master Alloy
Minimum purity	98.5%	99.0%	98.0%
Specific surface*	3300 ±200	400 to 700	1440 ±20
Particle size distribution	−1μ 46%	−1μ 35%	−10μ 71%
	1-2μ 43	1-2 45	10-20 20
	2-3 9	2-10 18	20-30 5
	3-5 2	10-45 2	30-70 4

*In sq. cm. per g. (see F. M. Lea and R. W. Nurse, *Journal* of the Society for Chemical Industry, Vol. 58, 1939, p. 277.)

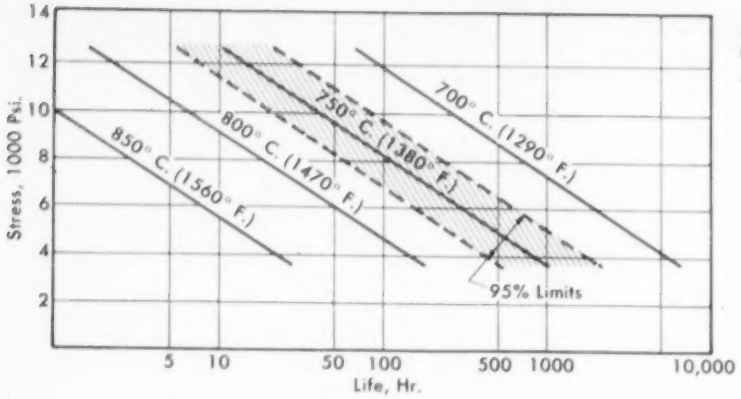


Fig. 3 – Stress-to-Rupture Curves for Sintered 64-30-6 Co-Cr-W Compact

Fig. 4 – Density of Sintered Compact Versus Life Under stress of 22,400 Psi. at 750° C.

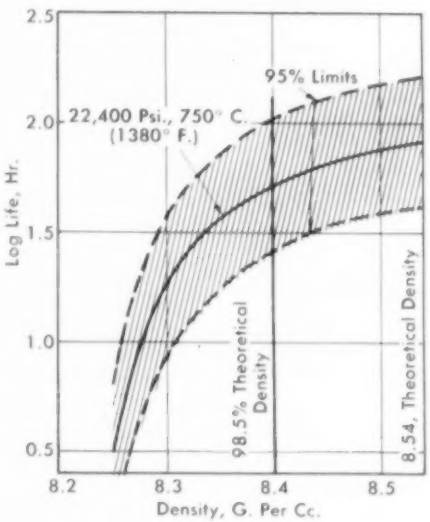


Table II – Physical Properties of 64-30-6 Co-Cr-W Alloy

Density, observed	8.44 G. PER CC.
theoretical	8.54
Mean thermal expansion, in. per in. per °F. × 10⁶	
70 to 1000 °F. (20 to 540 °C.)	7.95
70 to 1200 °F. (20 to 650 °C.)	8.45
70 to 1500 °F. (20 to 815 °C.)	9.08
70 to 1600 °F. (20 to 870 °C.)	9.27
70 to 1800 °F. (20 to 980 °C.)	9.95
At 1500 °F. (815 °C.)	9.86
At 1800 °F. (980 °C.)	11.65
Electrical resistivity, microhms per cm.	160 at 20 °C.*
Specific heat, g-cal. per °C.	0.087*
Thermal conductivity, Btu. per sq.ft. per ft. per sec. per °F. × 10⁴	4 at 1380 °F.*
Melting point	1400° C. (2550° F.)*

* Approximately

Preparation of Sintered Alloy – At the beginning, cobalt alloys appeared to be the most suitable, and the alloy finally accepted was basically one of the "Vitallium" series (64% cobalt, 30% chromium, 6% tungsten), approximating the American alloy known as "Stellite No. 22". The first aim of the work then became the production of a homogeneous sintered material having the lowest residual porosity.

The manufacturing method consisted of mixing powdered cobalt, tungsten and 50-50 Cr-Co master alloy. Table I lists the specifications for the powders. These mixed powders were pressed at 39 tons per sq.in. and loaded into a furnace, heated to sintering temperature, held for 12 hr. at 1300° C. (2375° F.) and cooled in the furnace using an atmosphere of pure hydrogen (dew point about –70° F.). Although there could be no liquid phase during sintering this powder mixture, the bars had high density, and porosity was not pronounced – see Fig. 1, typical microsections before and after etching. The over-all shrinkage on sintering corresponded to a linear shrinkage of about 10%, the product being only about two-thirds the volume of the compact.

Properties of the Sintered Alloy – The physical and mechanical properties of this sintered alloy are recorded in Tables II and III. Figure 2 shows the S-N curve obtained at 750° C. (1380° F.). Creep resistance, as assessed by stress-to-rupture tests for the as-sintered alloy, is shown for the range from 700 to 850° C. (1290 to 1560° F.) in Fig. 3.

Comparing the short-time tensile properties and creep resistance as published for Stellite 23 with our sintered alloy, it was found that the latter was similar in performance except that its creep resistance was rather inferior. Possibly there were two reasons – *(a)* the sintered alloy had not been aged, and *(b)* there had been no

deliberate additions of elements other than Co, Cr, and W, although additional constituents were known to be present in the cast alloy. (Eventually it was found that the creep resistance of the unaged sintered alloy was not improved by the addition of up to 0.5% of aluminum, boron, carbon or thorium oxide.)

Table III – Mechanical Properties of Sintered 64-30-6 Co-Cr-W Alloy

	70° F.	750° C. (1380° F.)	850° C. (1560° F.)
Tensile properties			
Proportional limit	78,500	50,500	33,500
Ultimate strength	100,000	77,500	47,000
Elongation on 0.625 in.	6.1%	7.6%	10.5%
Young's modulus	—	18,000,000	—
Stress for fatigue fracture in 300 hr. (40,000,000 cycles)		0 ± 23,500	0 ± 14,600
Vickers hardness	280 to 310		
Izod Impact	8 ft-lb.		

Since time was pressing and the sintered alloy met design requirements, we went ahead with the project with the simple alloy in the conditions noted above; improvements were to be considered later.

Stress-to-rupture tests (Fig. 3), obtained over a fairly long period, showed considerable scatter at a given load. This did not rule out the material for the turbine components, since the lowest creep resistance found with material of 98.5% minimum theoretical density was acceptable to the design. This scatter could be associated with at least four effects, namely:

1. Density has a profound effect on the stress-to-rupture life, as demonstrated by Fig. 4. In view of this, the alloy was used only if it had 98.5% theoretical density.

2. Unless special precautions were adopted, the powders apparently deteriorated on storage. For example, the following results were obtained with bars of similar density and made from the same powders, which were pressed and sintered respectively at the beginning and the end of a 12-month period, and tested at 750° C. under a stress of 22,400 psi.:

Table IV – Effect of Aging on Stress-to-Rupture Properties at 750° C. (1380° F.)

Condition	Load	Life	Elongation
As sintered	22,400 psi.	122 hr.	6.4%
	26,900	59	5.2
Aged 100 hr. at 700° C. (1290° F.)	22,400	554	10.0
	26,900	336	8.0
Aged 50 hr. at 750° C. (1380° F.)	22,400	554	6.1
	26,900	264	6.9
Aged 25 hr. at 800° C. (1470° F.)	22,400	570	7.8
	26,900	277	8.0

Powder as Delivered		Powder Aged 1 Year	
Life	Elongation	Life	Elongation
132 hr.	5.0%	72 hr.	5.0%
100	4.7	54	5.4
170	3.7	46	4.9

3. The 50% Cr, 50% Co master alloy had been made either by a thermit method, or by high-frequency melting in vacuum. Bars made with the former gave the best results but had greater

Fig. 5 – Lamellar Constituent Present in Specimens Made With Vacuum Melted Master Alloy. Fracture occurred in about 70 hr. 200 ×

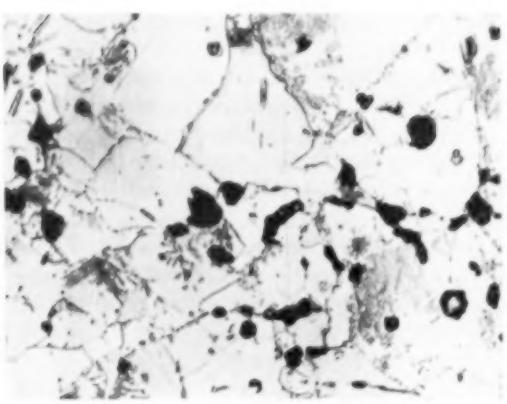
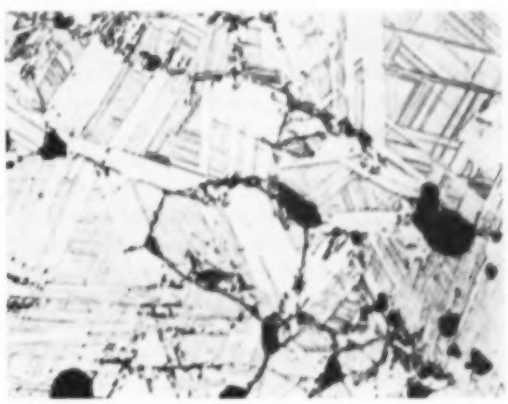


Fig. 6 – Precipitate Observed on Grain Boundaries, Twin Boundaries and Slip Planes in Specimens Made From Thermit-Prepared Master Alloy. Fracture occurred in about 445 hr. 750 ×



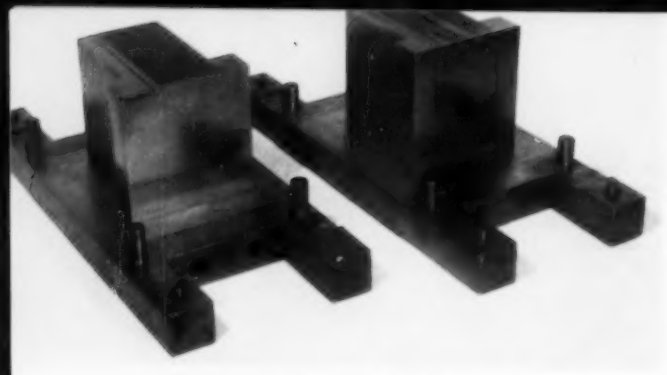


Fig. 7 – Serrated Punches for Pre-Pressing Powder Into Blocks for Nozzle Guide Vanes

scatter than those using the vacuum-melted alloy. Figures 5 and 6 illustrate microsections from ruptured specimens made with vacuum-melted and with thermit-prepared master alloy. (The latter specimen was obtained from a test bar having a life-to-rupture of 445 hr. compared with 70 hr. at 22,400 psi. and 750° C. for the one made with vacuum-melted Cr-Co master alloy.) While small amounts of a lamellar constituent were present in the specimen made with vacuum-melted Cr-Co alloy, there was less of this in the specimen using thermit alloy. In the specimen giving the longer life, a precipitate was also observed on some twin boundaries and slip planes – possibly associated with the enhanced properties. It was not identified, but it seemed to be similar to that reported in the work of Clauss, Signorelli and Weeton in Technical Notes No. 3107, 3108 and 3109 of the U.S. National Advisory Committee for Aeronautics.

4. Later experiments summarized in Table IV showed that aging (furnace cooling from the sintering temperature to the aging temperature and holding for an appropriate time) improved the life-to-rupture. The scatter of results was apparently less and possibly some of the scatter in the earlier tests was associated with the use of unaged alloy.

Manufacture of Components – In spite of the advantage of having components pressed to shape with integral roots, as can be done with powder metallurgy, we could save some time by producing blocks from which the required parts could be machined. As shown in the photograph at the head of this article, these blocks were to be T-shaped for root fixation and were of uniform thickness over the blade portion. To obtain the desired distribution of cooling passages throughout the blades, the pressings were built up in a number of layers, thus: A weighed amount of the powder mix, corresponding to a known thickness in the sintered state, was placed in the die cavity and carefully leveled. This was then lightly pre-pressed at 4500 psi., using a serrated punch (Fig. 7). Cadmium wires were then laid in certain of the grooves so formed, corresponding to preferred positions of cooling holes. Another weighed amount of powder was then placed on top of the wires in the cavity, leveled and pre-pressed and the process repeated as required.

A pair of serrated punches (the grooves being displaced, one punch to the other, by half a pitch) enabled us to arrange very close vertical spacing between wires, and therefore between the cooling passages. When the complete assembly had been built up in the die it was finally compacted at 39 tons per sq.in.

The cadmium was then completely volatilized (leaving behind the cooling passages) by heating the blocks under pure hydrogen at 0.1-mm. Hg pressure to 650° C. (1200° F.), well below the temperature at which the compacts consolidated. The cadmium volatilized through the pores without any ill effects on the subsequent sintering process. (If heating was too rapid, cracking occurred.) When the cadmium had been removed the blocks were transferred to the sintering furnace.

Machining the sintered blocks presented difficulties as there was no external evidence of the hole pattern on the blocks, although sectioning showed that the holes were reasonably accurately positioned. The method which was successfully used was to jig the blocks and to grind datum faces on two surfaces. Having established datums it was found that holes were always within 0.005 in. in relation to these; thus it was possible to machine the profiles around the holes without a break-through – in spite of the close proximity of some holes to the surface of the finished profile.

The experimental turbine for which these components were designed required 45 nozzle guide vanes and 99 moving blades. These parts have operated satisfactorily under impact of high-temperaturue gas, and it is estimated that the improvement obtained is equivalent to about 270° C. or 485° F. rise above the maximum temperature permitted, were the vanes and blades solid – that is, if the sintered alloy were uncooled.

The process described is proving to be of great value. Parts of this sort permit the accumulation of data on air cooling under actual running conditions in a turbine. Tests have been made at mean gas temperatures rising as high as 1120° C. (2050° F.).

Selection and Application of Furnace Atmospheres for Carbon Control

*By O. E. CULLEN**

A furnace atmosphere containing about 20% CO, 40% H_2 and 40% N_2 can be used to carburize, carbo-nitride, recarburize decarburized surfaces, clean harden or increase the carbon content of strip to a uniform higher level. Careful measurement and control of the dew point are needed to hold the carbon potential of the gas within the close limits required. (J 2)

THE TERM "controlled atmosphere" originally referred to any mixture of gases which prevented or minimized oxidation of the more common metals during heat treatment. Today, such use is only one of many and various combinations of individual gaseous constituents needed to meet the requirements of specialized heat treating processes. Compositions vary from that of a flue gas to essentially pure inert nitrogen or strongly reducing hydrogen, as shown in the table on p. 59.

All of these atmospheres are produced from hydrocarbon gases mixed with air or steam or both. Air is used where nitrogen is a major constituent and nitrogen can almost be eliminated by use of steam. Preparation of some of these atmospheres involves rather complicated chemical processes of absorption and catalytic

*Chief Metallurgist, Surface Combustion Corp., Toledo, Ohio.

Fig. 1 — Flow Sheet of Processes Used for Producing Generator Gases for Controlled Atmospheres

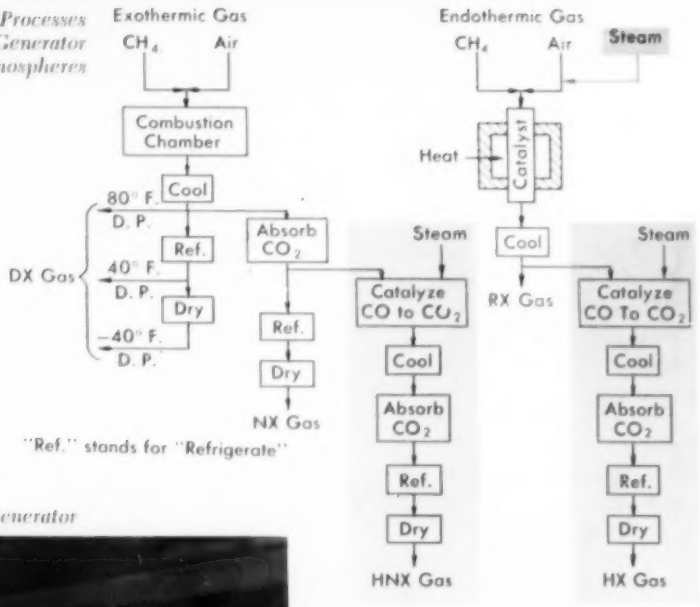
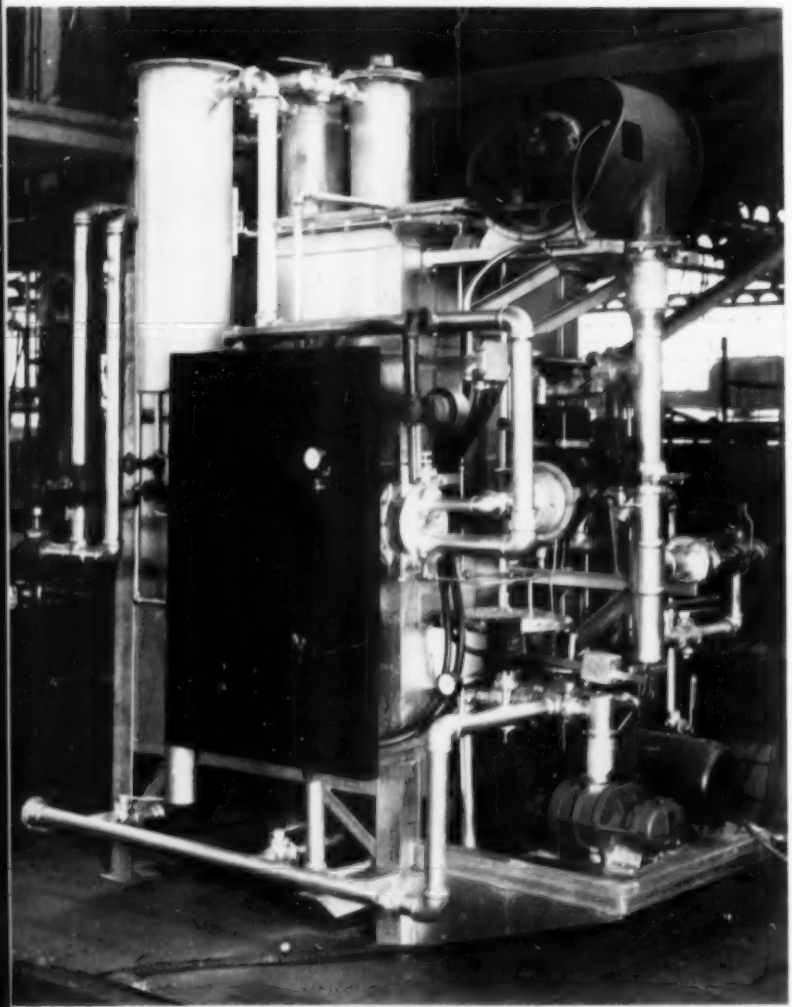


Fig. 2 — RX Endothermic-Type Generator



conversion in the final steps, as indicated in Fig. 1. Simplification of gas-generating equipment is a continuing research and development problem in our laboratory. The selection of the correct atmosphere for a particular application is critical. Not only must it contain the necessary major constituents to perform a given function, but it must be checked for minor constituents which often control the metal-gas reactions. An example of this need for controlling minor constituents is in processes involving carbon control. Today, practically all such processes, including gas carburizing, dry cyaniding, carbon restoration, homogeneous carburizing and clean hardening are carried out in controlled atmospheres produced by the endothermic type of gas generator shown in Fig. 2.

This RX generator gas is known as a 20% CO, 40% H_2, 40% N_2 type because of its major constituents. It is considered most suitable because of its relative freedom from the oxidizing or decarburizing gases, carbon dioxide and water vapor. Many papers and articles have been written about the im-

portance of these two minor constituents wherever carbon control is required, and it is accepted practice to control the carbon potential of this atmosphere by careful measurement of the water content, or dew point.

The 20% CO, 40% H_2, 40% N_2 type atmosphere was selected for such applications because hydrogen content must be in the proper range to tolerate water vapor in amounts suitable for accurate and easy measurement as indicated by the curves in Fig. 3.

The equilibrium curves for dew point versus carbon content at 1700° F. for endothermic atmospheres clearly demonstrate the advantage of using the 40% H_2 atmosphere throughout the entire range from 0.30 to 1.00% carbon. Within this entire range the equilibrium dew points are within limits of + 10 to + 40° F., the best range for dew point determination and – most important – for easiest operation of the endothermic generator.

Undoubtedly gas carburizing has created more interest in controlled atmospheres than any other metal treating process. The first continuous gas carburizing furnace ever built (and we are proud of the fact that it was a Surface Combustion furnace) is still in operation after 24 years of service. The gas carburizing process of that time would be hard to recognize today. In 1941 Surface Combustion installed the first endothermic gas generator for production carburizing and this generator is also still in operation. This endothermic generator opened the way to a new era in gas carburizing. Its purpose was to eliminate the problem of excessive soot deposition and thus improve alloy and furnace life and – of no small importance – to provide cleaner and more uniformly carburized work.

In the gas carburizing field it opened the way for meeting present-day requirements of high surface hardness, proper carbon gradients, and improved wearing quality, fatigue life and load-carrying ability of the processed parts. Today, it is the exception when specifications for gas carburizing operations do not mention the surface carbon limits. In almost every instance these limits are held well below the austenite saturation value, usually in the range of from 0.85 to 1.00% carbon.

The use of endothermic gas with dew point control has proven invaluable in setting up the proper atmosphere-carbon balance required for gas carburizing. In batch furnaces, dew points taken at regular intervals determine the amount of enriching gas, if any, that is needed at any particular time during the carburizing cycle. In continuous gas carburizing furnaces, dew points taken in the various zones along the length of the

Compositions of Generator Gases Used in Metal Treating

Type of Generator Gas	Composition, Percent by Volume*					
	CO_2	CO	H_2	CH_4	H_2O	N_2
DX gas (lean) 40° dew point	10.5	1.5	1.2	0.0	0.8	86.0
DX gas (rich) 40° dew point	5.0	10.5	12.5	0.5	0.8	70.7
NX gas	0.05	1.5	1.2	0.0	0.0	97.25
HNX gas	0.05	0.05	3.0 to 10.0	0.0	0.0	Bal.
RX gas	0.0	20.7	38.7	0.8	0.0	39.8
HX gas	0.05 to 2.0	0.05 to 1.0	50.0 to 99.8	0.0 to 0.4	0.0 to 3.5	Bal.

*Compositions are based on use of natural gas as the base gas for atmosphere production.

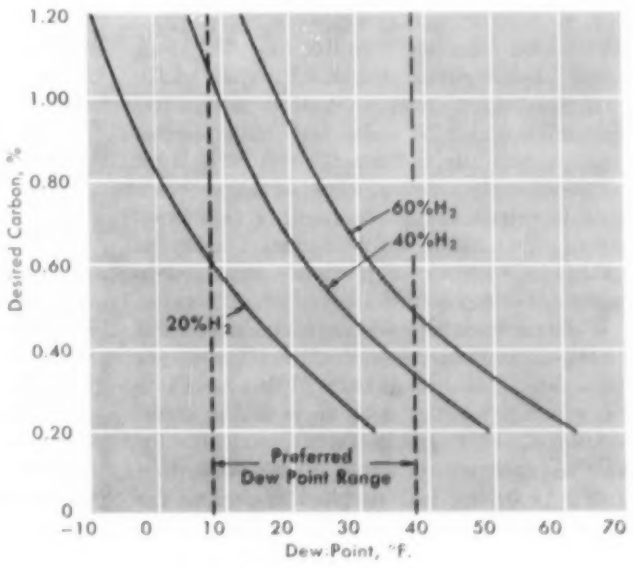


Fig. 3—Carbon Control by Dew Point With Furnace Atmosphere Containing 20% CO and Variable H_2 Contents with N_2 Balance at 1700° F.

furnace indicate the amount of enriching gas required in that zone. By proper manifolding of atmosphere gases to the furnace zones, the amount of enriching gas can be independently controlled.

Under certain conditions, where the RX generator gas must be maintained at a high dew point – for example, in a particular zone of a furnace – metered additions of air can be made to the atmosphere.

Control has been successfully maintained manually with samples analyzed at frequent intervals with a dew point cup or a recording instrument reading but we now have available fully automatic continuous dew point controlling instruments.

The atmospheres used for dry cyaniding or carbo-nitriding consist of mixtures of endothermic gas, hydrocarbon enriching gas and ammonia. The additions of ammonia vary in amount over quite a range depending, of course, on the type of case desired, temperature of treatment and type of steel being treated.

Quite recently, we had occasion to review the operations of a number of controlled atmosphere furnaces being used for dry cyaniding. A partial list of the products being treated included transmission gears, shifter forks and rails, clutch-release forks, steering-gear parts, timing and crankshaft sprockets, oil-pump shafts, washers, hand-brake levers, screws, bolts, nuts, sheet metal stampings, bushings, valve lifters, fasteners and ball studs.

The temperature of these furnaces ranged from 1425 to 1650° F. and the case depth specifications varied from 0.0005 to 0.030 in. The steels being used included the S.A.E. and A.I.S.I. 1000, 1100, 1300, 3100, 4000, 4100, 4600, 5100, 8600, 8700 and 9400 series with initial carbon contents generally in the range of 0.08 to 0.20% but occasionally running as high as 0.40% carbon. In a few instances previously gas carburized parts (with 0.050 to 0.070-in. case) were given a thin-case (0.10 in.) dry cyanide treatment to improve wearing qualities.

While most of the work was oil quenched and a small amount water quenched, some parts were atmosphere cooled to produce file-hard surfaces for wearing qualities with very ductile cores. Atmosphere cooling is particularly valuable for wear resistant parts of the type where distortion during quenching is a problem as well as for large parts requiring high core ductility.

The hydrocarbon gas added to these furnaces

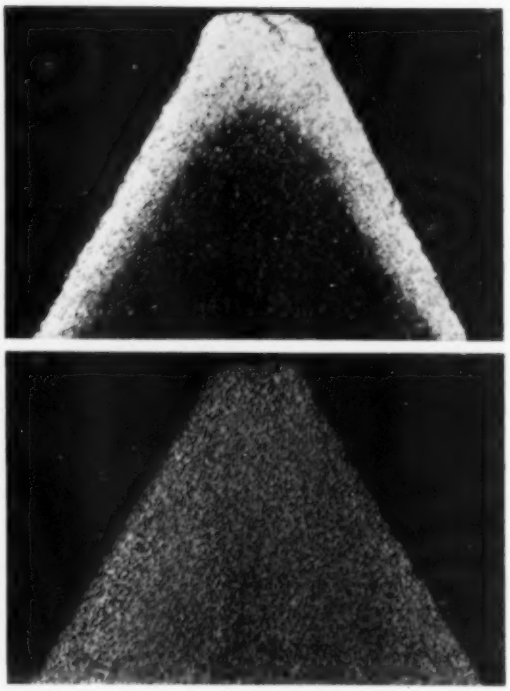


Fig. 4 – Rolled-Thread Cap Screw Decarburized for Easier Fabrication and Subsequently Recarburized and Hardened

was generally controlled to maintain between 2 and 5% methane in the furnace atmosphere regardless of the treatment. On the other hand ammonia additions varied from 0.5 to as high as 25% of the total atmosphere admitted to the furnaces. The lower percentages were used when cyaniding the high-carbon steels, while the higher percentages were necessary to produce high-nitrogen cases for full hardening without benefit of oil or water quench.

Carbon Restoration

The process of carbon restoration actually became a reality in an automotive manufacturer's plant. During World War II the process was used quite extensively to reduce scrap losses of strategic materials and to recover badly needed production parts with excessive surface decarburization. At the present time carbon restoration is used during the processing of carbon and low-alloy steels in bar, rod and wire shapes, so that they can be hardened without removing decarburized surfaces.

The carbon restoration process has a number of applications in the manufacture of finished

Fig. 5 – Group of Fasteners Formed From Low-Carbon Steel Strip, Then Homogeneously Carburized to Higher Carbon Levels

steel products. One excellent example is the very successful use by manufacturers of the heat treated rolled-thread bolts shown in Fig. 4. If carbon restoration were not employed in the heat treatment of these bolts, it would be necessary to remove the decarburized skin prior to rolling the threads. Actually it was found that die life for upsetting and thread rolling was improved considerably by using a decarburized bar or wire. Carbon restoration during hardening served the double purpose of improving die performance and insuring the quality of the finished product.

Homogeneous Carburizing

Homogeneous carburizing is one of the newer heat treating processes which would not be possible without the use of modern controlled atmospheres. The process consists essentially of raising the carbon content of a low-carbon steel to a uniform medium or high-carbon level throughout the section. In one instance strip samples of 0.08% carbon steel of various thicknesses from 0.010 to 0.090 in. were simultaneously carburized to a uniform content of 0.40% carbon. By use of RX generator gas of proper dew point for carbon control, it was possible to heat all samples for the maximum time required to homogeneously carburize the heaviest section without overcarburizing the thinnest.

The principal advantage of this process is the ease in forming parts from low-carbon steel with attendant savings in die costs, steel cost and scrap losses inherent in cold forming medium and high-carbon steels. Also it avoids the possibility of large batch rejections due to intermixing with off-specification steel. Finally, it has the advantage of using one low-carbon steel to obtain different carbon contents specified in the finished products. Figure 5 shows some excellent examples of the kind of parts suitable for homogeneous carburizing.

Conclusion

Thus, we have traced the history of one type of controlled atmosphere which has contributed so much to the carbon control processes in the heat treating field. The other types of controlled atmospheres were developed because of similar important needs in other metal treating processes. The problems involved were different, and so were the types of atmosphere, but substantially the same need remained for balancing the composition with the metal being treated.

Some of the other atmospheres will undoubtedly become important as heat treating processes change and new ones are added. Entirely new types of controlled atmospheres will undoubtedly be required in the future. Heat treat progress does not stop and the development of controlled atmosphere generators will certainly not be found lagging behind.

Atomic Reactors for Power*

ADVANCED power reactor technology was emphasized by several of experimental reactor projects.

First of these is a boiling water reactor wherein the steam is generated at the core itself. It is known as the Experimental Boiling Water Reactor power plant (EBWR), designed to produce 20,000 kw. of heat and 5000 kw. of electricity, the minimum which would enable sound extrapolation to large-size central station power plants. It is now under construction at the Argonne National Laboratory. The boiling water reactor for which Commonwealth Edison and associates have requested a license would carry this type to the full-scale stage.

A sodium-cooled, graphite-moderated experimental reactor (SRE) of 20,000-kw. heat capacity is being built by North American Aviation at Santa Suzanna, near Los Angeles. Original plans did not provide for generating steam or electricity, but a contract is being negotiated with the Southern California Edison Co., to install and operate a turbine-generator plant, without cost to the Government, pay the Commission 45¢ per million Btu. for the heat, and publish the information developed.

Design of the second Experimental Breeder Reactor (EBR-2) is well underway. The plant will be sodium-cooled,' will generate 62,500 kw. of heat and 15,000 kw. or more of electricity. A half scale, non-nuclear mechanical model has demonstrated the technical feasibility of operating mechanisms in sodium at temperatures of 700° F. The hydraulic characteristics of the sodium-coolant system and the performance and reliability of the electromagnetic coolant pumps are being determined. Construction of EBR-2 will start in 1956 at the National Reactor Testing Station in Idaho.

Homogeneous Reactors are also under close study. In them the fuel material is evenly mixed throughout the moderator, which is usually heavy water. Such a power reactor would have high power density and low fuel inventory, remove fission products and radiation damage products continuously, have a high degree of nuclear stability, and no fuel elements or control rods. The Homogeneous Reactor Experiment No. 2 (HRE-2) now under construction at Oak Ridge National Laboratory will operate with a dilute heavy-water solution of "enriched" uranyl sulphate containing 95% of its uranium as U^{235}, and it will be eventually blanketed with a slurry of thorium oxide in heavy water [to breed U^{233}].

The Pennsylvania Power & Light Co. and the Westinghouse Electric Corp. have notified the Commission that they are working on the development of a full-scale homogeneous atomic power plant which will utilize this technology.

Experimental projects include homogeneous reactors using a uranyl phosphate solution in a tall cylindrical pressure vessel which contains not only the fuel solution but also the heat exchanger or boiler for the generation of steam. Thus, circulation of the highly radioactive fuel solution outside the pressure vessel is avoided. Another project will use hydrocarbon diphenyl as moderator-coolant. The potential advantages are low induced radioactivity, low corrosion of fuel elements, and high boiling point. This was selected as the best of five designs submitted to the Commission.

The Engineering Test Reactor, a companion to the Materials Testing Reactor and a major tool for the development of all types of reactors, is to be built at the National Reactor Testing Station.

Shippingport — Substantial progress was made in the construction of the nation's first large 60,000-kw. civilian nuclear power plant — the Pressurized Water Reactor at Shippingport, Pa. Westinghouse Electric Corp. is designing and fabricating the nuclear portion; Duquesne Light Co. the conventional portion and will operate it upon completion.

Naval Reactors — The USS Nautilus, powered by the Submarine Thermal Reactor, Mark II, has steamed in excess of 25,000 miles, including a cruise, submerged, from New London, Conn., to San Juan, Puerto Rico, a distance of more than 1300 miles at an average speed of about 16 knots. The reactor continued to operate satisfactorily. The prototype plant is being refueled after 30 months' operation.

Submarine Intermediate Reactor (SIR) Mark B, to power the submarine Seawolf, is under construction at Knolls Atomic Power Laboratory, Schenectady, N.Y. The submarine's hull was launched in July. (SIR) Mark A, the prototype, operating at West Milton, has been delivering power to Niagara-Mohawk Power Co. A contractor is being sought to accept this power at the bus bar at the established price of 3 mills per kw-hr.

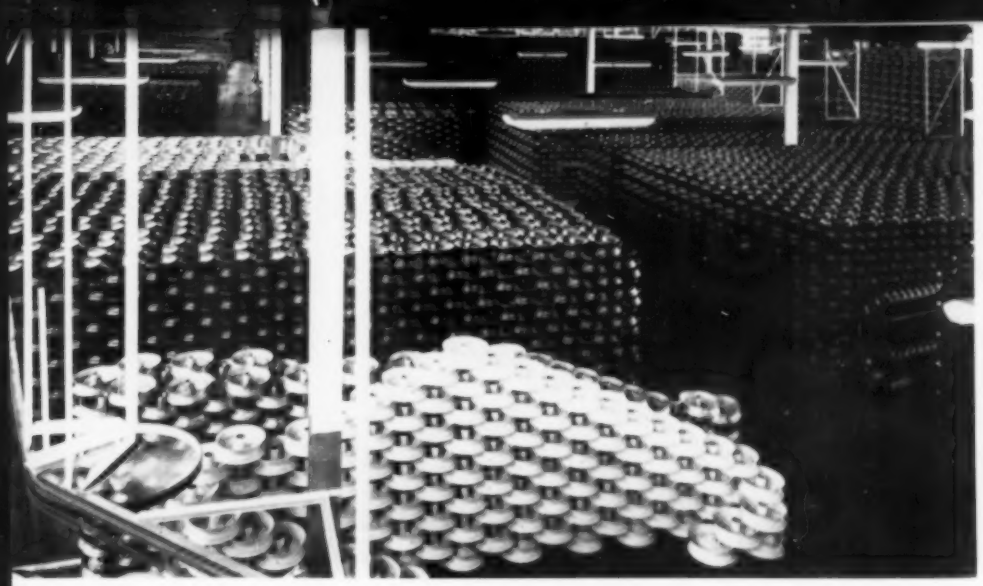
Work on the Submarine Advanced Reactor (SAR) continued at the same locality.

Design and development work on the Large Ship Reactor (LSR) is continued by the Westinghouse Electric Corp. Construction of the prototype will commence in the spring in Idaho.

Army Reactors — The objective of the Army Reactor Program is land-based package reactor systems suitable for meeting heat and power requirements of the military services in remote areas. Army Package Power Reactor (APPR-1) will be a pressurized water reactor producing 1825 kw. of electricity; it was begun at Fort Belvoir, Va., by Alco Products, Inc., as prime contractor. Argonne National Laboratory is studying a boiling heterogeneous reactor power plant for military use, having an output of about 200 kw.

Aircraft Reactor — The aircraft nuclear propulsion program was accelerated, and the prospects for nuclear-powered flight continue to show promise. Test facilities at National Reactor Testing Station were completed and test work commenced.

*Extracts from 19th Semiannual Report of the Atomic Energy Commission to the Congress.



Wheels and Wheel-and-Hub Assemblies Awaiting Shipment From Finished Wheel Storage Department at Motor Wheel Corp.

Manufacture of Spot Welded Automobile Wheels

*By MILTON H. GRAMS**

Replacing of riveting lines by four-gun spot welding machines relieved a bottleneck in the production of automobile wheels. The welded wheels are stronger and can be assembled automatically with greater control of quality. (K 3)

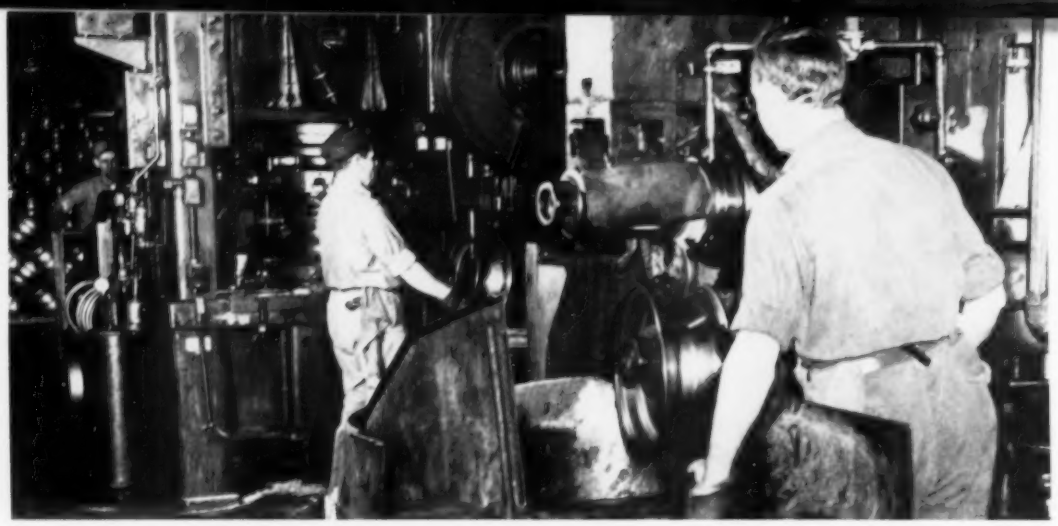
MODERN automobile wheels differ but little in basic design from prehistoric man's log slices but the job they are called on to do is far more exacting. They must be as light as possible to reduce unsprung weight to a minimum, yet they must be strong enough to withstand the high torque, impact and bending stresses imposed by today's high-speed travel. From a manufacturing standpoint, they must be produced in large quantities at a reasonable price while being held to close tolerances of dimensions, concentricity and balance.

Except for a few special kinds, practically all present-day automotive wheels are of the steel-disk type, consisting of a channel-shaped drop-center steel rim mounted on a circular disk. The disk is formed in a series of press operations from hot rolled steel strip similar in analysis to A.I.S.I. 1015. It is usually circular with a center hole for receiving the axle hub, circumferentially spaced holes for the fastening bolts, and a peripheral flange for attachment to the rim.

In some models this peripheral flange is continuous around the entire circumference of the disk, but in most wheels the flange is interrupted by four equally spaced scallops which provide a gap between the disk and rim for attaching anti-skid tire chains. In these latter wheels, the flanged areas are referred to in trade parlance as "spokes".

The rim is also made from low-carbon hot

*Chief Metallurgist, Motor Wheel Corp., Lansing, Mich.



Partially Formed Rims Are Given Final Contour in "Finish-Roll" Machine and Expanded in a Press to a True Circle. The expanding operation also acts as a further test of weld quality

rolled steel strip. Cut lengths of the strip are coiled and welded into a continuous circular hoop by high-speed flash-butt welding. After removal of the welding flash the flat hoops are passed through a series of rolling and press operations which give the rim its final drop-center shape. The finished rim is then expanded to a true circle and to its final size in a press equipped with expanding dies. Since the rim is stretched beyond its yield point in the expanding operation, this step also serves as a test of the quality and strength of the flash-butt weld. The final step is a visual inspection. With the advent of the tubeless tire, inspection of the butt weld assumed critical importance, for in addition to its old function as a tire carrier, the rim must now also serve as an airtight pressure vessel in which no leaks can be tolerated. Experienced inspectors set aside any rim that might possibly develop an air leak at the weld and these rims are tested in a fixture which subjects the weld to air pressure.

Prior to World War II and for some time thereafter it was common practice among makers of automotive wheels to join the disk and rim together with soft steel rivets. Although riveted wheels were entirely satisfactory from a performance standpoint, their manufacture had many disadvantages. Riveting lines took up a lot of space and the assembly of the wheels required much handling. Many wheels had to be repaired because of mix-up in rivet sizes, misplaced rivet holes or off-center peening.

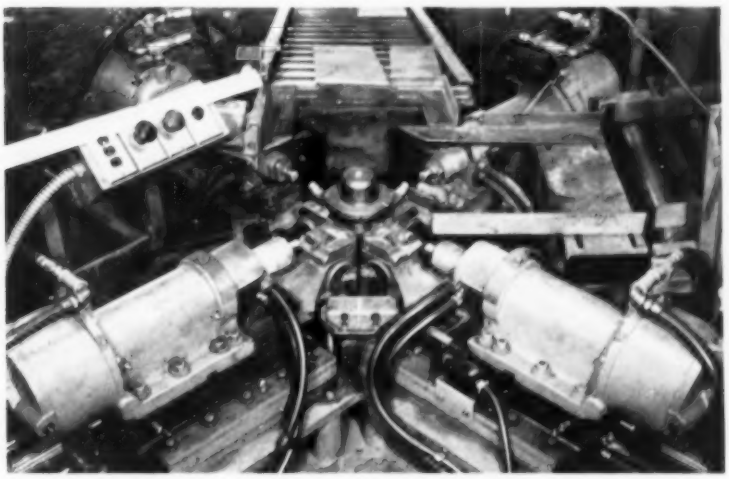
To eliminate these problems and to meet ever-increasing production schedules, a better method of making wheels had to be found. Further incentive was furnished by the fact that heavier and faster cars required stronger wheels while the development of the tubeless tire posed the problem of building a wheel with an airtight rim. Having gained valuable experience with various methods of welding on defense work during the War, Motor Wheel's manufacturing department decided that spot welding was most promising.

After studying various welding techniques and the various types of welding machines available, a single-electrode machine using three-phase current and an electronic control circuit was purchased from Sciaky Bros. of Chicago. During the ensuing months, thousands of experimental wheels were welded on this machine. Changes were made in the welding heat, welding pressure, and the size and shape of the electrodes until good-quality welds of the desired size were produced consistently. As each change was made, the welds were tested by pushing the disks out of the rim. In the metallurgical laboratory shear tests were made on individual welds and cross sections were examined under the microscope. In addition, welded wheels were subjected to impact tests and rotational fatigue tests in the laboratory and to severe service tests on the road. The results of all these tests proved beyond doubt not only that welded wheels were much stronger than riveted wheels but also that high-quality welds could be consistently produced at a rate adequate to meet production schedules.

Sample welded wheels were submitted to the engineering departments of the various customers, where the wheels were subjected to further rigorous testing. In every instance, the welded wheel was approved for use. Limited production was begun on a "four-gun" Sciaky machine which made four welds at a time. During this pilot stage, the testing program was continued and changes were made in the machine

to increase reliability and reduce maintenance time. After some 2,000,000 wheels were produced, orders were placed for production machines. As the machines became available, the riveting lines were replaced by welding lines without any interruption of production. In all, 12 wheel welding machines are in use at Motor Wheel, arranged in four lines of three machines each.

The welding machines are a "table-top" design with the welding heads mounted on a cabinet base which encloses the transformers and the necessary air, water and electric power lines. This type was chosen because it permits the machine operators and maintenance men ready access to all the working parts. The design was



Pilot Model of Four-Gun Spot Welder Showing the Four Pairs of Opposing Electrodes. Wheel to be welded is moved in from right-hand side and, after welding, is ejected at the back

considered somewhat unconventional at the time because of the possible danger of damage to the transformers from water leaks, but this hazard was eliminated by completely waterproofing the transformers with a special sealing compound in addition to the usual baked varnish coating.

Each machine has four transformers rated at 125 kva., one for each welding gun. The four guns are mounted horizontally on the top of the cabinet base and are spaced 90° apart. The guns are essentially heavy-duty air cylinders with cylindrical rams, or pistons, that move into and out of welding position on gibbed slides. Each ram carries a copper block serving as a holder for a removable electrode. The ram has a maximum stroke of 3½ in. which can be adjusted to accommodate the various sizes of wheels. The welding guns are connected to their respective transformers by flexible laminated conductors. Both surfaces of these ribbon conductors, as well as all secondary circuit connections, are silver-plated to minimize corrosion and resistance to current flow. At the center of the top, opposite each welding gun, is an adapter which carries an inner electrode aligned with the outer electrode on the welding gun. During the welding, both electrodes grip the wheel with a pressure of 4500 lb. After the weld is completed, the outer electrode retracts sufficiently to clear the outer edge of the rim while the inner electrode retracts inward about 1/16 in. to avoid contact with the disk when the wheels are removed or dropped in place for welding. A post at the center of the top serves as a pilot to center the wheel and hold it tightly during welding.

Each welding cycle consists of three steps:

1. *Squeeze time* during which the electrodes close on the wheel and clamp the two layers of metal together.

2. *Heat time* when the electric current flows through the metal and forms the weld.

3. *Hold time* when the current is off but the pressure is continued to prevent expulsion of molten metal and to control the cooling of the weld nugget.

By means of the electronic control circuit the time interval of each of these steps is controlled precisely to the nearest cycle of current. Six ignitron tubes convert the secondary current from alternating to pulsating direct current. During the heat time, this rectified current is fed to the electrodes in a series of impulses with brief interruptions to allow the heat generated to spread evenly through the metal. A typical heating cycle would be nine impulses, each impulse consisting of four cycles on and four cycles off. The control system also provides

Wheel Is Shown After Welding Is Completed With Outer Electrodes Retracted

circuit interlocks and safety cutouts which stop the machine if any detail of the operation is out of adjustment. For example, a limit switch prevents the start of the welding cycle until the wheel is properly aligned with the electrodes. Also, other controls stop the machine if the line voltage, air pressure or water pressure drops below preset values.

When a particular size of wheel is scheduled for assembly, the disks and rims are moved from storage to the welding line. Disks are pre-washed, but rims are washed just prior to assembly in vertical washers at the head of each line. As a clean dry rim emerges from the washer it is positioned in a press along with a disk and the two are pressed together tightly to insure intimate contact between the two metal surfaces. After the assembly is checked on a spinning fixture for lateral and circumferential runout, it is placed on a sloping conveyer belt which carries it up to the level of the welding heads. As the wheels move past, the operator of the welder slides a wheel off the conveyer over flush guide rails onto a vertically movable table, the table descends and the wheel comes to rest on the center post. Air-actuated steel fingers move out of the post to grip the disk at the edge of the center hole as the wheel actuates a limit switch to start the welding cycle. The welding guns move into contact with the wheel, four welds are made simultaneously, and the guns retract. The disk is indexed manually by the operator and the welding cycle is repeated, after which the wheel is raised to the level of the discharge chute and is ejected from the machine as another wheel is moved into position.

The welded wheels move on conveyers to a station where the valve-stem hole is pierced in the rim. After inspection, the wheels are conveyed to the finishing room where they are painted or bonderized to order, then to the shipping department to be stored or loaded directly into trucks or railroad cars for delivery.

The production of consistently high-quality spot welds on wheels at the high rate of speed demanded by production schedules requires close control of all phases of the operation. The material in the disks and rims must be sound and of uniform analysis, the surfaces of the parts must be clean and free of oxide scale and the two parts must fit tightly together. With these factors established, welds of uniform size and strength depend on close control of such factors as electric current, time and electrode pressure. Of particular importance are the current density and the unit pressure at the contact faces of the welding electrodes. These two elements are determined by the magnitude of either the current or the pressure and by the contact area of the electrode. The electronic control circuit referred to above accurately controls the magnitude of the pressure and welding current, leaving the contact area of the electrode as the most critical item to be controlled.

Spot welding electrodes are made of a high-copper alloy because they must have high conductance, and are made large enough to hold their shape when subjected to heavy pressure. If the temperature of the electrode is allowed to climb too high, the electrode will begin to "mushroom"; that is, the contact area will increase in size. As the contact area enlarges, the

unit pressure and current density will obviously drop until these values are too low to bring the metal parts to their welding temperature and a poor weld, or no weld, will result.

Too much heat in the electrode will allow the formation of a nonconductive film of copper oxide on the contact face which will inhibit the flow of electric current. To keep the temperature of the electrodes at a minimum, internal cavities are machined in the electrodes through which water at about 50° F. is circulated under pressure at a rate of about 3.5 gal. per min. for each electrode. To avoid clogging of the water lines by hard mineral deposits, softened city water is recirculated through a closed system. The heat is extracted by passing the water coming from the electrodes through a tubular heat exchanger. By keeping the electrodes cool, as many as 60,000 spot welds have been made from one electrode, the average life of an electrode being around 40,000 welds. To make sure the contact face of the electrode maintains its proper size and shape, the electrodes are inspected periodically and touched up by hand if necessary.

Each wheel has eight spot welds – two welds per spoke. A typical weld size is ⅜ × ⅝ in. Numerous tests on individual welds of this approximate size indicate that their shear strength is 12,000 to 15,000 lb. By way of comparison, each of the twelve ½-in. diameter rivets in a riveted wheel has a shear strength of 3000 to 3200 lb.

As a check on weld quality, wheels are periodically removed from the line and placed in a hydraulic press where the disk is pushed out of the rim. In this test, the welds are considered satisfactory if they remain intact and a section of either the rim or disk the full size of the weld nugget is torn out. At the least indication of a departure from this standard, the welding machines are checked and adjustments made until full-size "slugs" of parent metal are pulled in the weld test.

By constant attention to every detail of the welding operation and frequent testing of the wheels, Motor Wheel has compiled the enviable record of more than 26,000,000 spot welded wheels without a single reported field failure.

Production Control of Salt Baths in Germany

*By OTTO SCHAABER**

Potential of bath is measured by immersing mild steel foil long enough to carburize throughout and estimating its carbon content; quenching power of martempering bath is measured by time needed to heat a small cylinder through a specified range. (J 2)

IN GERMANY, salt baths are used for a much greater proportion of heat treating than in the United States and more attention has probably been devoted to their control in production. The instruments and methods used for temperature control are similar but methods for control of other variables recently adopted here are more or less unknown outside Germany. A short survey may be useful to the readers of *Metal Progress*.

Naturally, the main attention in control practice is concentrated on the property or

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properties considered to be most important for each specific application of salt baths. In one group of applications the salt has both a physical and a chemical function, with the latter more important. The main purpose of the salt is to change the composition of the workpieces to be treated (at least in their surface layers) by chemical reaction with the steel surface. The most important field of application is liquid carburizing; others are liquid cyaniding and nitriding. In carburizing (and partially in cyaniding) the salt acts chiefly as a carburizing medium, and for a long time efforts have been concentrated on closer control of this carburizing action. In most shops little or no attention is paid to the control of the physical effect – heat transfer, in this particular field of salt application – although it is a desired and necessary effect.

Fig. 1 – Foil Specimen as Prepared for Immersion in Salt Bath

The second group covers all fields of heat treating where salt is used primarily as a heat transfer medium.

Salts are used as heating mediums in hardening of constructional, case hardening and tool-steel, and as mediums for maintaining a definite temperature in such applications as isothermal annealing and austempering, and as quenching mediums in salt quenching high speed steel, austempering and marquenching. A chemical effect is definitely undesirable since the composition of the steel surface must not be altered during such heat treatments. Therefore, in addition to controlling the heat transfer properties, it is essential to check the carburizing or decarburizing tendency of the baths.

The Foil Method

Since the inactivated straight cyanide baths are gradually being superseded by activated baths with about 10% cyanide, the traditional check of the carburizing efficiency of the bath by means of a chemical analysis of the cyanide content is no longer sufficient. The cyanide content in activated baths is only one of several factors influencing the bath efficiency. The next logical step is chemical analysis of the activator content; however, activators are seldom simple compounds and analysis of only one component does not necessarily measure the efficiency of the whole activator complex. Very few shops have been experimenting with this method and still fewer are using it. A quick direct check of the carburizing properties of a salt bath is obviously necessary. A direct check means that the carburizing effect itself should be measured and not the amount of one or more components of the carburizing medium which influence it. The check must be quick – that is, the time should be short compared with the normal carburizing time.

The demand for a direct check led to the introduction of a method now commonly referred to in Germany as the "foil method". A very thin piece of steel will carburize to a definite homogeneous carbon content within a short time if the bath has a carbon potential lower than the saturation carbon content of the steel test piece at the temperature of carburizing. Turnings and razor blades are not satisfactory.

About five years ago, the use of foils 0.05 mm. (0.002 in.) thick was suggested. Such foils can be manufactured to close thickness tolerances so that the influence of thickness variations on the carburizing time can be neglected. They can be purchased with a high surface polish so that the surface quality and the ratio of surface to volume are always the same. At any rate, experience has proved that within the same bath and the same temperature the time for thorough carburizing is reproducible and constant.

Usually such foil material is purchased in strip form, 30 mm. wide. Two carbon contents are common: about 0.10% and about 1% C. Unalloyed steel is preferred for reasons which will be discussed later on. A piece about 100 mm. (3.94 in.) long will yield about a gram of material for carbon determinations. The sample must be degreased by one of the common degreasing agents, such as trichlorethylene, and should be carefully dried before immersion into the salt bath. It is common practice to pierce the

foil and to handle it by a soft iron wire as shown in Fig. 1. It is sometimes difficult to immerse the thin foil in baths with a relatively thick carbon cover and occasionally it is difficult to overcome the surface tension of the liquid salt with the thin soft foil. Experiments are under way to develop other forms of samples with somewhat greater rigidity.

Recommended immersion times for thorough carburization of the 0.05-mm. foil in an activated bath at various temperatures are:

Temperature		Immersion Time
800° C.	1470° F.	60 min.
850	1560	30
890	1630	15
930	1710	10

The sample foil should be quenched into cold water and cleaned carefully. If no chemical apparatus for carbon determination is available, a simple bend test will give some indication of carbon content. If the hardened foil has a brittle fracture when bent slightly, the carbon content is higher than 0.5%. It is, however, common practice to determine the carbon content with the well-known volumetric method based on the Orsat principle of CO_2 absorption.

Some people consider the necessity for a chemical apparatus a disadvantage of this method, because it is either necessary that the heat treating department should have such an apparatus with a skilled man to handle it, or the samples must be sent to the chemical laboratory which means delay. Therefore, some attempts have been made to shorten the time for the carbon determination. For example, in one laboratory an improved volumetric method was introduced which involved two consecutive absorption vessels, and the volume measured without adjustment to atmospheric pressure. This laboratory reports good results and remarkable savings in time. However, the method has not yet found wide acceptance.

Attempts to determine the carbon content of the foil by magnetic means have failed so far, yet the author feels that the magnetic method should be investigated more thoroughly because it might result in a simple test, where the operator would only have to read a dial. Another possibility, the change-in-weight method, has not yet been adopted but is at present undergoing practical tests in the author's laboratories.

The carbon content of a thoroughly carburized foil is generally considered to equal the carbon potential of the salt. However, this

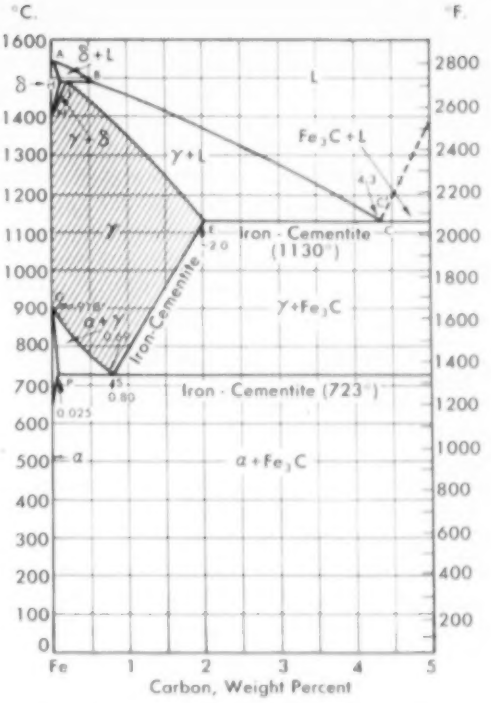


Fig. 2 – Shaded Area of Iron-Carbon Diagram Indicates the Region of Carbon Potential for Which Foil Test May Be Used

general statement is not unconditionally correct. The carbon potential of a carburizing medium can only be exactly measured by the foil method if the carbon lies within the homogeneous austenite range of the foil material. If the foil is made from unalloyed carbon steel, which is common practice, incontestable results are only obtained in baths, the carbon value of which is within the range given by the lines GS and SE in the iron-carbon constitution diagram. Fig. 2. At a temperature of 800° C. (1470° F.) it is just possible to determine a maximum carbon potential of 1.0%. If the carbon potential is higher, the results of the foil test are of doubtful significance. When the austenite is saturated and still more carbon is available, carbides are formed, and with very prolonged immersion time the carbon content of such a foil may theoretically reach 6.7% – the carbon content of the iron carbide. Should the foil material contain alloying elements, such as chromium, which tend to narrow the homogeneous austenite range, it is even impossible to determine a carbon potential of 1.0% at 800° C. Similar limitations are true for salts with a carbon potential so low that it lies to the left of the line GS.

Shop Routine – If the foils are only used within their homogeneous austenite range, the carbon potential of activated carburizing baths can easily be controlled and regulated to the desired level. It is, of course, easier to do this with baths which are run continuously at the same temperature and with a constant carbon potential. Similar loads will further facilitate the operation. Under such conditions experience has shown that it is quite sufficient to make only one foil determination per shift. There are even heat treating departments where – despite very high quality standards – it is thought that the necessary uniformity can be achieved by only one foil determination every 24 hr. It is, of course, absolutely necessary that the necessary additions be weighed exactly and added at regular intervals. The conditions are more complicated when either the bath is not run continuously and is cooled down after one or two shifts, or when the carburizing temperature and time must be changed often because of different parts to be carburized. If a high standard in surface carbon content is to be maintained, a foil check will be necessary before every new load. Such conditions may occur in small shops and with commercial heat treaters. Any change in temperature will disturb the equilibrium within that bath; the same applies when parts with different ratios of surface to volume are carburized.

Identical results with the simple foil tests do not always mean that the carburizing behavior of the salts tested is similar. For example, the carbon content of foils immersed in two different baths for 20 min. may be the same even though one reached the equilibrium value in 2 min. and the other in 20 min. There is no question that the cases produced from these baths during manufacturing operations with standardized times would have different properties.

To prevent difficulty under such conditions it is advisable to prepare curves showing carbon content as a function of foil immersion time. Such curves not only give a more accurate picture of the activity of the bath but also may be used to schedule additions of carrier salt, carburizing compound and activator.

Nonactivated salts have no definite carbon potential – or perhaps more exactly, their carbon potential is so high that it cannot be measured. Probably the theoretical carbon potential is 6.7%. These baths have, on the other hand, a very low rate of carbon transfer; that is, it takes a very long time to reach equilibrium between bath and steel. The low rate of carbon transfer is a very important property of these baths, for otherwise it would be impossible to avoid too high a surface carbon content with subsequent carbide formation in the surface layers. Determination of the carbon potential is virtually impossible but these baths may be successfully controlled by a curve of foil carbon versus carburizing time.

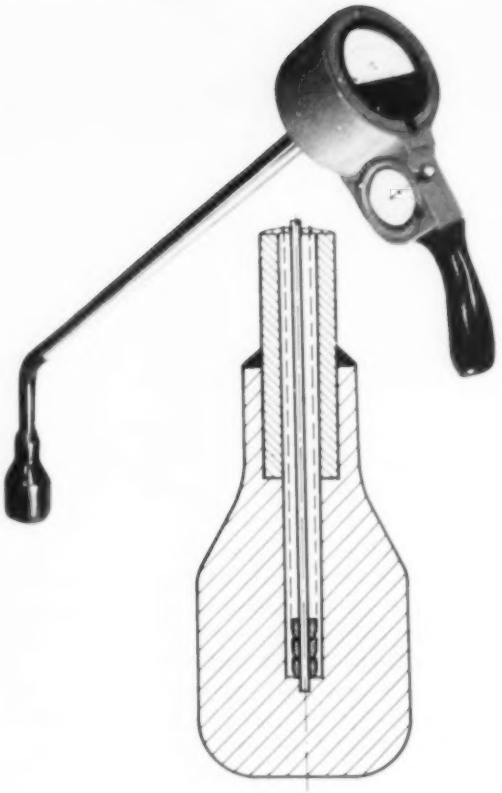


Fig. 3 – Apparatus Used to Measure Quenching Rate of Salt Baths

When salt baths are used for hardening steel, the major control problem is the prevention of any change in chemical composition of the steel surface. Theoretically there are three ways to avoid chemical reaction: (*a*) Use heating mediums that do not react with the metal; (*b*) adjust the carbon potential of the bath so that it is the same as the surface carbon; and (*c*) use a mixture in which the rate of carbon transfer is so low that the surface carbon is not influenced within the times used in practial hardening.

No commercial salt mixtures will remain completely nonreactive in practical operation, so either alternate (*b*) or (*c*) is used, the former for hardening of constructional and case hardening steel, the latter for tool and high speed steel. Both may be controlled with carbon-time curves.

(In practice high speed steel hardening baths are checked with the simple foil test using foils with a carbon content of 1.0 to 1.1%. After immersion they must not show any decarburization.)

The recommended immersion times for decarburization control are:

Temperature		Immersion Time
800° C.	1470° F.	30 min.
900	1650	20
1000	1830	15
1100	2010	10
1200	2190	5
1300	2370	3

Quenching Power Tester

The most important property of salt baths used for quenching is their ability to extract heat uniformly from the parts to be quenched at such a rate that no undesirable transformation products are formed during quenching. On the other hand, no chemical reactions are admissible either between the quenching salt and the steel surface or between the quenching salt and drag-outs of high-temperature salts used in the heating cycle.

In salt quenching of high speed steel there is usually no problem in attaining the necessary quenching power. Actually, difficulties have been reported because some baths have too high a cooling speed and thus crack tools that had been successfully quenched in oil. The reason was that salt does not show any Leydenfrost phenomenon and its quenching power at high temperatures may be higher than that of oil.

The low cooling rate of the salts used in austempering and marquenching of constructional steels is the most severe limitation of these methods. Methods of improving quenching rate by change in salt bath design have been adopted in both Germany and the U.S.A. but the approach differs. Whereas in America efforts are being made to concentrate the maximum flow of salt in certain restricted working areas and to separate the high-temperature salts continuously, the German approach has been to develop designs which are sturdy and inexpensive with only a general agitation by pumps or stirrers.

High-temperature salts are separated preferably during weekend shutdowns if the cooling power is too adversely influenced. The unfavorable effect of high-temperature salts on the quenching rate of nitrate-nitrite baths is well known but separation is expensive and can't be done too frequently. Common practice is to heat the mixture to about 350° C. (760° F.) with pumps or stirrers shut off, then pour into a conical container and allow to cool. The high-temperature salts settle and can be broken away from the frozen cone head.

This problem stimulated the development of a special device for measuring the quenching power of salt baths in commercial practice. This instrument, shown in Fig. 3, has now been adopted by a large number of shops for a standard check. The quenching power of a quenching medium (this device is extensively used for control of other quenching mediums, too) is measured by the cooling rate in the center of a 2-in. diameter cylinder made of an unalloyed carbon steel similar to S.A.E. 1015. Temperature scale and a stop watch are in the handle so that the instrument is self-contained. Because an unalloyed steel is used for the test head, heating must be done in salt baths to prevent excessive scaling; carburizing or hardening baths are normally used. The test head is immersed until about 720° C. (1330° F.) is shown on the scale. When the instrument is taken out and held in still air, the temperature will first rise and then fall. When about 710° C. (1310° F.) is reached, the test head is immersed into the quenching medium to be tested. Originally it was recommended that the cooling time between 700 and 400° C. (1290 and 750° F.) be used as a base for evaluating the quenching power of salt baths but this could not be confirmed in practice. The maximum allowable cooling time should be measured under the special individual conditions of the shop. As experience has shown, this makes it possible to maintain constant cooling rates in commercial practice without continuous salt separation by either filling up with fresh salt, adding water or by separating chloride salts in the way described earlier.

There are some limitations. For example, the cooling time is measured in the center of a 2-in. cylinder and the cooling times in the center of other diameters are not necessarily proportional. Furthermore, the present form of the test head does not yield the exact conditions of a cylinder since the distance between the thermocouple and the end of the cylinder is less than the theoretical value of three times the diameter. Therefore, the cooling rate in the center of a long 2-in. cylinder is not the same as that of the test head center. However, these limitations do not restrict in any way the value of this instrument for practical control of quenching power of commercial baths, or for evaluating heating rates in hardening baths.

Biographical Appreciation

Conrad F. Nagel, Jr.
Vice-President and Chief Metallurgist
Aluminum Co. of America

THE CAREER of a man who has thoroughly distinguished himself in a field of applied science such as metallurgy, yet commands the especial respect of his associates for his untiring effort to promote teamwork, in contrast to individual star play, may seem somewhat of a paradox. In the life of Conrad Frederick Nagel, Jr., vice-president and chief metallurgist, Aluminum Co. of America, it is not.

When "Dutch" Nagel joined Alcoa in 1915 (Bachelor of Chemistry, Cornell University), he became only the second man in the Aluminum Co. of America whose duties were concerned with technical aspects of the manufacture of aluminum products. This work was under the direction of Dr. Earl Blough, who started in 1905 with the Pittsburgh Reduction Co., Alcoa's infant predecessor. Dr. Blough's duties, in his own words, were concerned with "anything pertaining to aluminum technology".

In 1915, the company was manufacturing pig and ingot, sand castings, sheet, wire, cable and cooking utensils. Alloys were limited to a few simple combinations. The field for development was wide, and Mr. Nagel was confronted with varying tasks. One of his early investigations was the improvement by heat treatment of the hardness and strength of aluminum alloys containing copper and magnesium – an extension of Wilm's famed findings in Germany in 1911.

This investigation was interrupted by World War I which required Mr. Nagel's direct attention in the military forces from May 1917 to July 1919. He lost no time, when war's end brought his release from the 79th Division of the U.S. Infantry, with the rank of first lieutenant, in returning to the job that was awaiting him with Alcoa, at New Kensington, Pa.

Alcoa's experience and growth during the First World War prompted a realignment of its technical activities; one of the important steps was the organization of the technical direction bureau, with Dr. Earl Blough as technical director. The principal responsibility of this bureau was the introduction and application of control measures into aluminum and aluminum alloy fabrication, and the development of new practices, processes, and products. Mr. Nagel was placed in charge of one division of the technical direction bureau, and was appointed assistant director of the bureau in 1923, his principal concern being with wrought products.

In 1928, he was placed in charge of the newly organized metallurgical department, fabricating division. In 1944, he was appointed chief metallurgist, operating department, which put him in charge of all metallurgical activities in the smelting, fabricating, and castings divisions of the Company. In ensuing years, he was appointed chairman of Alcoa's technical committee, which guides and supervises all of the Company's technical activities, and of the research policy committee, which guides and supervises the research program.

He was elected vice-president of Alcoa in April 1952. One of his outstanding technical achievements was the investigation of reasons for the excessive corrosion of aluminum in aircraft structures during the early years of its use for airframes. The aircraft industry had turned to aluminum with enthusiasm; in fact, the first all-aluminum airframe was built in about 1922. Little attention was paid to the possibility of corrosion effects, and when severe corrosion did occur, doubts regarding the suitability of aluminum for airframe construction were soon raised. Mr. Nagel not only enlisted the aid of Alcoa's technical facilities and those of the aircraft manufacturers, but also devoted a considerable part of his own time to this problem. Through these combined efforts the causes of excessive corrosion were found and corrective measures developed. These involved not only improved heat treatment and elimination of certain alloys, but development of protective coatings and even of assembly procedures which recognized this hazard. The practices used today to avoid corrosion of aluminum in aircraft can be traced back to that work, and the aircraft industry now considers that the corrosion of aluminum is no longer a serious problem.

Nagel's individual accomplishments are covered by patents and technical papers issued in his name, and by numerous developments for which he was personally responsible. Moreover, his advice and counsel have contributed significantly to most of the outstanding technical developments of his organization.

The efforts of this man to foster the spirit of teamwork in activities he participated in have already been mentioned. In the past 35 years the technical activities of Alcoa have grown as the Company has grown; new groups have been organized and individuals have been promoted. All of these people were understandably anxious to gain recognition in their progressing careers. That they could be absorbed into the organization and come to appreciate that advancement is more certain by demonstrating effectiveness as a cooperating member of a team than by striving

for singlehanded accomplishment is evidence of Mr. Nagel's leadership and administrative ability. The result has been accomplished by example and suggestion without imposing any limits on the initiative or activities of the individual.

Those who have worked in close contact with him gain certain clear-cut impressions which help to explain his attitude.

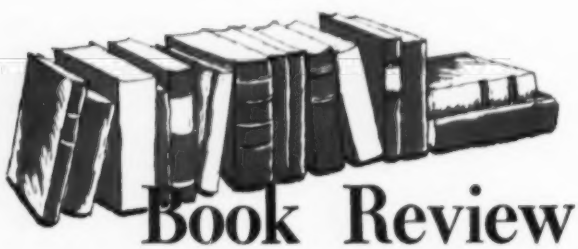
Where technical matters are concerned, he is factual, first of all. He has been called "Get-the-Facts-Nagel". When available facts are presented, the conclusions are drawn on the basis of these facts, but action is decided on the basis of the conclusions – plus other influencing considerations which must be taken into account. Intellectual honesty and integrity are a part of this picture.

He possesses humility. He fosters teamwork by example. His colleagues can recall no instance where Dutch has even suggested that he should be given "credit" for a development. His success should be ample evidence that humility brings its own recognition.

He possesses simplicity. This is best illustrated by his direct manner; the meaning of his statements and writing is seldom misinterpreted or misunderstood, nor is it necessary to wade through laborious and roundabout side issues to get at the point he is making.

In earlier days, Mr. Nagel could boast of occasionally breaking 80 in golf, and his regular opponents have been known to sputter at his deadly accuracy near and on the green. In recent years, however, fishing seems to have relegated golf to second place among his hobbies. A mounted specimen on the wall of his study commemorates a big moment of triumph, when in 1949, he pulled a 7-lb., 6-oz. small-mouth bass from Rock Lake, Ont. – the largest caught in that area in many years.

Dutch's interest in promoting personal and friendly relations among those who work together is just one manifestation of his friendly nature. He would not, under any circumstances, miss the annual reunion of a group from the 79th Infantry Division of World War I and rarely turns down an invitation that offers an opportunity to renew acquaintance with old friends and make friends of new acquaintances. He likes people, and people like him.



Book Review...

A World Text on Chromium Plating

*Reviewed by G. DUBPERNELL**

CHROMIUM PLATING, by P. Morrisset, J. W. Oswald, C. R. Draper and R. Pinner, Robert Draper, Ltd., Teddington, Middlesex, England. 1954. 586 p., $11.

While chromium plating is to a considerable extent an American development, the first comprehensive and up-to-date book on the subject was written by a French author, Paul Morisset, in 1952. No less important is Mr. Oswald's excellent translation into English which is supplemented by additional material on decorative chromium, a historical introduction, and chapters on regeneration of solutions, waste disposal, health hazards and costs contributed by C. R. Draper and R. Pinner. The bibliography has also been supplemented so that there is a total of

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425 references compared to 243 in the French edition. A good index is also included.

The book is replete with curves, charts, illustrations and line drawings which generally help to make the information clear and readily available. The principal precaution in using the book as a working manual is to realize that the units used are British and must be converted to U.S. units. Thus the familiar concentration of 250 g. per l. of chromic acid becomes 40 oz. per gal. instead of 33.3 oz. per gal., since the British imperial gallon is equivalent to 1.2 U.S. gallons.

Paul Morisset has been the director of the "Centre d'Information du Chrome Dur" in Paris since World War II. He has done a remarkable job of collecting, correlating and translating information on chromium plating for French workers. A byproduct of this activity has been a series of monthly bulletins, annual reports and several books. A further result is that the present book is strongly slanted toward hard chromium plating rather than decorative applications even though the Britsh authors have strengthened the latter section. In fact, the strengthening process has been carried so far that one might question as "padding" the inclusion of detailed information on other matters such as preparation of the basis metal, cleaning, copper plating and nickel plating in a book on chromium plating.

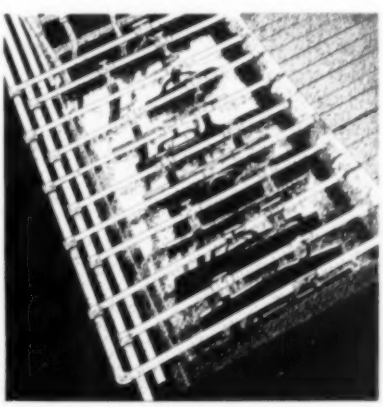
In a more critical vein, quite a few shortcomings may be noted. Mr. Morisset's introduction should not have been omitted and the new historical introduction leaves much to be desired. A fallacious theory of the value of small concentrations of trivalent chromium permeates a number of chapters. This creates some confusion in view of the recognized injurious effect of larger amounts of trivalent chromium. While the translation into English is of uniformly high quality throughout, one slight lack was noted where "SO_4" was translated as "sulphuric acid". This is indicative of an undesirable type of loose thinking since the sulphate ion is a primary variable in chromium plating.

Some misspellings and typographical errors in the bibliography in the original French edition were carried over into the English instead of being eliminated. On the whole, however, the bibliography is quite accurate. It is also in alphabetical arrangement and is thus self-indexing. More serious is the claim that "it is believed that it contains all the more important papers published before January 1954". While articles and patents on chromium plating have appeared at an almost constant rate for the last 30 years and number in the thousands, an analysis of the 425 references showed that almost 60% of them covered the years 1948 to 1953 inclusive with very limited coverage of the period 1925 to 1945. The bibliography is thus not nearly as well-rounded as one might suppose. This is the more surprising since Morisset published a different book on chromium plating in 1948 which contained over 1000 references – his "Repertoire Technique des Applications Industrielles du Chrome Dur".

Another feature of the book which may be either praised or criticized at times is that a considerable number of Morisset's curves and charts represent his own studies of the data published by others and should be used with caution. At least five or six bright-plate range charts from different sources are presented, resulting in what may be an unnecessary profusion of data. These may be useful but more of the data should have been in their original form.

The book is thus characterized by an abundance of data, much of which is in an unfamiliar form that tends to be confusing and some of which is inaccurate or contradictory. For example, five methods are given for the determination of trivalent chromium. While this may be of interest to some research workers, the average user of the book will have difficulty in deciding which method is most suitable for his use.

All criticisms aside, we have at last a worthwhile, comprehensive and up-to-date book on chromium plating which is of wide usefulness. The newer SRHS baths and other processes are more or less adequately treated, largely on the basis of available publications. Extensive cross references help to unify the material and to permit locating everything on a given subject. The book can be recommended most strongly to the specialist in the field. It will probably be found less useful as a working manual for a beginner, or as a textbook for the practical worker, but the reviewer does not know of any other more suitable book.



How Statistical Techniques Solve Metalworking Problems Part II

By CHESTER R. SMITH*

If enough time is devoted to preplanning and statistical design of experiments, considerable savings can often be realized. An example is given of a designed experiment that required less than half the time and material a conventional investigation would require. (S 12, Ti)

IN THE FIRST part of this article in the February issue two examples were given of the use of statistical techniques and statistical inference in the analysis of production data. In this part, an example of the design of an experiment to study the effects of an alloying agent in titanium is presented.

The Mallory-Sharon Titanium Corp. conducts both basic and applied research. This experiment was conceived and conducted by the basic research group; however, the same methods, design and analytical techniques are used in the solution of production problems. The technique is particularly applicable to production problems where several variables are involved, and where it is desirable to know which combination of the variables produces the best result.

In designed experiments there should always be a planning period to determine in advance exactly what is the goal of the experiment and more particularly the limitations of the design. Often the goal of a project is obtained in a stepwise fashion with a series of successive experiments. Whenever such a program is planned, an outline of the possible results of each step can be most revealing to the entire group working on the experiment.

In each step of an experiment it is essential that the goals be defined with respect to whether an effect or an optimum is desired. I have seen programs fail because the goals were not definite — for example, when an experiment is run to ascertain whether effects are present and then the question is raised as to what level of the variables produces the optimum effect. Both questions cannot always be answered by the same experiment unless it takes into account that both an effect and an optimum are desired.

Effects in an experiment are classed by effects

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either on the variability or on the average of the test results. Variables investigated in this kind of experimentation are so arranged that a statistical analysis will tell whether one variable or a combination of the several variables produces significantly more or less variability in the test results and whether the variables produce significantly higher or lower average test results. This kind of experimentation is usually employed in stepwise research programs.

On the other hand, most production problems are of the optimum-type design. The effect of the variables is known and the significant variables are searched for the best combination. It is possible to design one experiment to determine both effects and optimum if there is an optimum combination of variables in the range studied.

As an example, our research group wanted to know the effects, if any, of an alloying addition

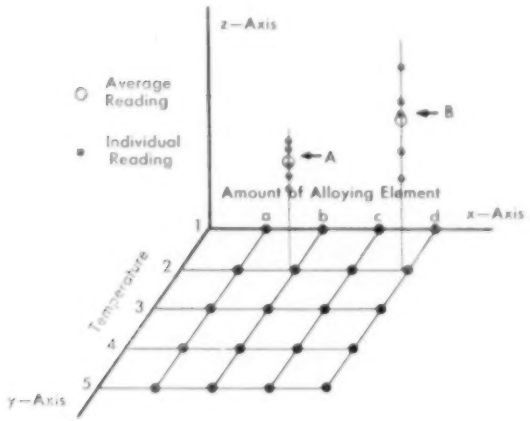


Fig. 1 — Geometrical Representation of Conventional Experiment Designed to Measure the Influence of Two Variables

to a standard alloy and the optimum effect, if any, of varying heat treatment temperatures. As usual, several percentage levels of the alloying element and several heat treatment temperatures were selected, and the following table was prepared to exhibit the proposed design and number of ingots to be melted:

Heat Treat Temperatures	Amount of Alloying Element			
	a	*b*	*c*	*d*
1	1a	1b	1c	1d
2	2a	2b	2c	2d
3	3a	3b	3c	3d
4	4a	4b	4c	4d
5	5a	5b	5c	5d

Total of 20 Ingots Required

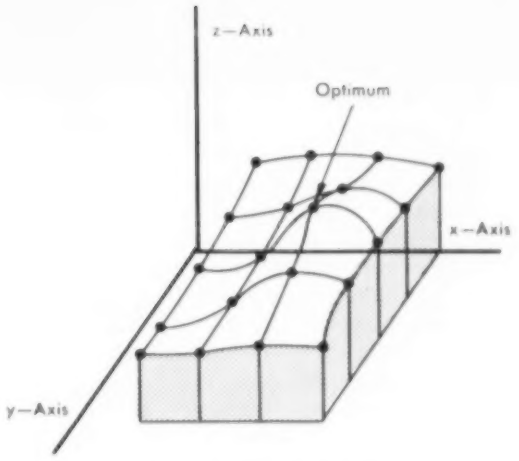
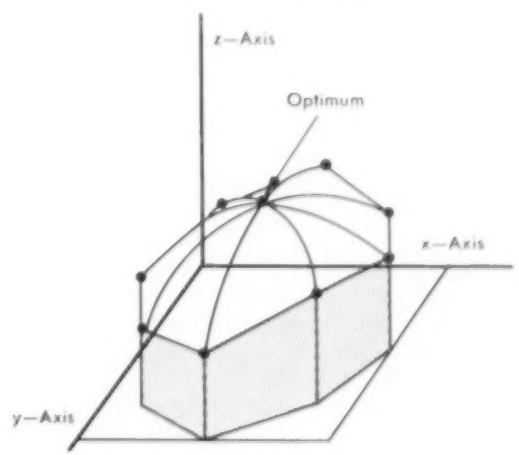


Fig. 2 — Average Results for 20 Tests Produce a Surface Pattern That Indicates the Optimum Combination of Variables

The results of such an experiment are pictured geometrically in Fig. 1. It was drawn while the experiment was still in the planning period to "see" what the results desired and planned would look like. The x-axis is the amount of alloy added; the y-axis, heat treatment temperature; and the z-axis a particular property of the ingots.

The test results, plotted on this three-dimensional drawing, form a surface. The height of the surface at the various points above the x-y basal plane is used for statistical analysis of the averages. The scatter of the test results at any one point on the surface is measured for statistical analysis of the variability. Point A has less variability than point B and also has a lower average. Statistical analysis would evaluate

Fig. 3 — Statistical Design of the Experiment Reduces the Number of Tests From 20 to 9 Yet Produces the Same Result



whether these differences are significant or occurred by chance alone.

A geometrical picture of the proposed design is shown in Fig. 2. An optimum exists when the surface under consideration has a peak or plateau, and movement in any direction away from the optimum produces either a significantly different average result or a significantly different variability in the results. Such surfaces can be any shape that reaches a maximum or increases regularly as the variables on the x and y-axis are changed.

If 20 tests were conducted in the pattern shown, the results would indicate a high point on the surface plotted. Unfortunately, it requires 20 ingots to locate this optimum. Suppose we consider a different mathematical spacing of the points in the basal plane and construct a three-dimensional diagram of the test results as shown in Fig. 3. Note that the existence of an optimum is still evident even though this surface contains only nine points.

It is logical to follow the second scheme since the percentages of the element to be added and the heat treatment temperatures selected by the metallurgists are intended to bracket an optimum, if it exists. Therefore, little harm can be done by chopping off the corners of the first diagram since seldom in practice do the outlying edges produce an optimum on the surface generated by the pattern in the table. Even if an optimum is not found but there are indications that the surface is increasing at one of the edges, an extension, in any direction, is possible. Even with an extension, the number of points would still be less than 20. Once an optimum is bracketed, new ingots around this location on the surface can pin-point its exact location, still with less than 20 points, or ingots.

The nine-ingot design produced results similar to the pattern indicated by Fig. 3. There was a drastic change in tensile properties with one combination of heat treatment temperature and content of alloying element. Subsequent statistical analysis showed that there was not a significant change in the variability but that there was a significant change in the averages at the optimum point.

It is worth noting that this entire problem was almost solved graphically. An extension of this design to more variables of classification cannot be drawn pictorially; instead one must resort to mathematical formulas in n-dimensional spaces. Once the concept can be visualized in three-dimensional space, the extension is easily accomplished. Statistical analysis and formulas are employed merely to test whether the results are significant.

The entire planning period and the analysis of the results require about 25 hr. of statistical work. However, the same design has been used since, with little or no assistance from the statistical group. Planning saved about $800 worth of titanium ingots and about 60 laboratory man-hours the first time it was used. These two items more than offset the cost of the planning and the analysis; yet they yielded powerful inferences about the test results.

In the entire discussion of this problem and the design of the experiment, an attempt has been made to show several points or concepts:

1. The design of an experiment should be prefaced by a planning period in order to outline the goal in terms of effects or optimums.

2. Lay out the program, usually by a block diagram, so that each step from the beginning to the end of the experiment can be seen and a model, either pictorial or mathematical, can be used to depict the results of the experiment.

3. Manipulate the model to ascertain whether the aims of the experiment will be attained. An enumeration of the possible results will help to guide this manipulation.

4. Conduct the experiment as designed and use statistical analysis to determine whether the results are significant.

In these two articles I have not intended to expound the theory of designed experiments or statistical analysis but hoped to stimulate an interest in the possibilities of such techniques in the metalworking industries. I wanted to show that results are sometimes significant when, at first glance, they do not appear to be significant and that many hours of unnecessary work can often be saved by considerate planning and careful execution of a designed experiment. Sometimes the results of an experiment seem straightforward, but the statistical approach to the design and subsequent analysis add greater power to our inferences from the test results.

The benefits derived from the approaches we have discussed are sometimes difficult to measure in dollars or manpower, but over a period of time the entire approach of any industrial organization becomes more scientific, which leads to quicker, more efficient solution of its problems. Statistical quality control has shown a tremendous influence on industrial products in America today. Statistical inference can have the same powerful effect.

Predicting Corrosion Resistance by Microscopic Examination

By JOHN H. SCOTT*

Stainless steel plates which must pass a 240-hr. nitric acid corrosion test can be released for shipment while the test is in progress by use of a quick microscopic screening method. (R 11, SS)

A MAJOR problem in production of stainless steel plates is the measurement and control of corrosion resistance. Usually samples from each plate size and each heat must be tested in boiling nitric acid for five 48-hr. periods and the entire test cycle normally takes two to three weeks to complete. If plates are held until corrosion tests are finished, they create an expensive storage problem; on the other hand, if they are released for further processing or shipment, money will have been wasted in treatment of plates that should have been rejected, or customers may receive defective material.

Streicher described in *A.S.T.M. Bulletin* for February 1953 a simple, rapid test for screening stainless plates by microscopic examination of specimens electrolytically etched in 10% oxalic acid. For Types 304 and 304 L, if any grain is found to be surrounded by a carbide formation, the material must be subjected to the nitric acid test. If carbides are present but do not surround any grain, the material is classified as a dual structure and passes the test. A structure with no carbide formation is rated as a step structure and also passes.

We tried the Streicher test on 20 samples of Type 304 L but found that only a very small percentage of the material was acceptable. The same samples were subjected to the 240-hr. nitric acid test and all were satisfactory, with corrosion rates well below the specified maximum rate of 0.002 in. per month. Actual rates ranged from 0.0006 to 0.0012 in. per month with no definite relation to the findings in the Streicher test. The amount of material approved by the quicker method was helpful to our production departments but there wasn't enough of it. The necessary work, such as shearing, physical testing and preparation for shipment, was still delayed until the nitric acid test was completed.

An additional 50 samples of Type 304 L were prepared using the electrolytic oxalic acid procedure, but instead of determining only if any surrounded grains were present, a complete study was made of each sample. The gage, grain size, surface condition, number of grains ditched in a given area and the general amount of ditched structure were recorded and the samples were also classified as to whether they had a ditch, dual or step structure. Again a very low percentage passed the one-grain-surrounded criterion. A structure which passes both the oxalic acid and nitric acid tests is shown in Fig. 1. No surrounded grains were found in the sample. The structure shown in Fig. 2 is that found most often in Type 304 L. There are a number of surrounded or ditched grains present so that the plate would not be passed in the Streicher test yet it will have a low nitric acid corrosion rate. A structure which failed both types of testing is shown in Fig. 3. Most of the grains are surrounded and the grain size is smaller than that of samples which pass the nitric acid test.

With the information gained on this survey, 200 additional samples were examined and rated

*Chief Chemist, Lukens Steel Co., Coatesville, Pa.

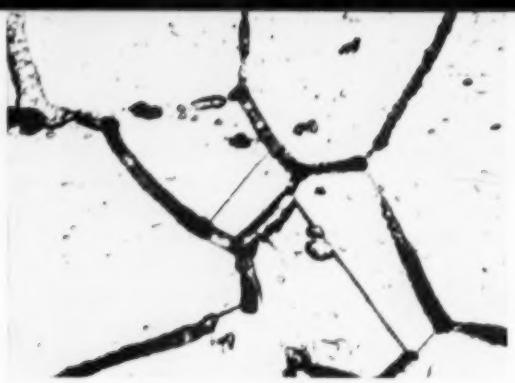


Fig. 1 – Structure of Type 304 L in Which no Grain Is Completely Surrounded or Ditched. This sample passes the Streicher test and has a corrosion rate of 0.0009 in. per month in boiling nitric acid. Oxalic acid etch; 500 ×

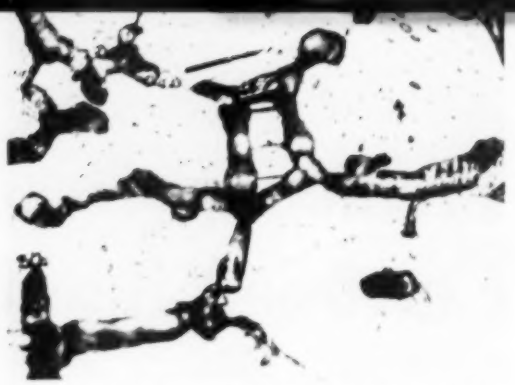
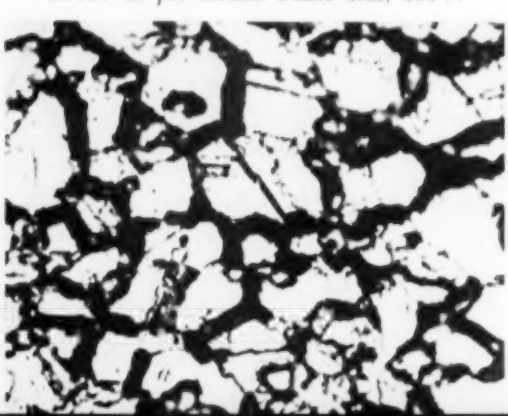


Fig. 2 – The Surrounded Grain in This Sample Would Cause Rejection in the Streicher Test. The corrosion rate in boiling nitric acid is 0.00085 in. per month. Oxalic acid; 500 ×

in two ways. Twenty plates were passed by the Streicher method and 159 were passed using the prediction system based on a thorough examination of the sample. Six samples were predicted to fail the nitric acid test and 15 were rated as questionable. The results were very gratifying since all the "predicted-to-pass" samples did pass the boiling nitric acid test with low corrosion rates. Four of the six predicted failures did occur; that is, they had corrosion rates over 0.0020 in. per month. Of the 15 questionable, only two failed but most of them had corrosion rates in excess of 0.0012 in. per month.

This system is now standard production procedure and is applied to all Type 304 L which requires corrosion tests. More than 3500 samples from plates ranging from 3/16 to 3 in. thickness have been checked and all of the predicted "passes" had corrosion rates under 0.0020 in. per month. One or two samples showed rates over 0.0015 in. per month, but none higher than 0.0018 in. per month. Most of the questionable samples, which now amount to approximately 10% or less, show increased rates but usually pass the corrosion test. Most of those classed as failures do fail the boiling nitric acid test. We are able to give immediate production releases for 85 to 90% of the plates examined whereas less than 20% could be released by the Streicher test.

Fig. 3 – Structure That Fails Both Oxalic and Nitric Acid Tests. Corrosion rate is 0.0023 in. per month. Oxalic acid; 500 ×



The specimen is taken from a test coupon cut from the corner of each plate after annealing. For Type 304 L the coupon is sensitized at 1250° F. for 1 hr. and water quenched. The sample is cut off with an abrasive wheel and polished to 400-grit finish on a wet paper wheel. It is then etched in 10% oxalic acid for 1½ min. at a current density of 1 amp. per sq. cm. All specimens are examined at 500 × magnification and it is possible for an experienced technician to rate a sample in two or three minutes.

Plates which are predicted to fail are returned immediately for further heat treatment. Those predicted to pass are completely processed and prepared for shipment or shipped to the customer. As soon as the results of the nitric acid test are available, they are used to certify the corrosion rates of the "predicted-to-pass" plates.

Much more experience is required for our modified test than for the Streicher test but we have found that it takes only a week to train a technician with previous microscopic experience to perform the prediction test satisfactorily. For training we use a series of specimens taken from corrosion tested plates that represent all the structures that will be encountered in production samples. The micrographs shown on p. 80-B illustrate some of the structures encountered and we instruct the technician how and why each is rated. We stress the importance of examining each sample thoroughly to be sure that an average condition is used for rating.

The only material for which we use the modified test is Type 304 L in plate form. We have examined other forms of Type 304 L and also some Type 304 and 316 samples but we have not yet examined a sufficient number of samples to recommend adoption of the modified test.

Inco high temperature research note:

Carburization

...and its effects on metals at high temperatures

With sufficient background of information on the strength properties and corrosion characteristics, it should be entirely possible to predict the performance of an alloy under any conditions of high temperature service.

Method of Obtaining Data

Data relating to the mechanical properties may be obtained in the laboratory by any of the conventional testing methods . . . on the other hand, the problem of high temperature corrosion resistance is often so complex that it is frequently more convenient to place test specimens in an actual service environment than to try simulating industrial conditions on a laboratory scale.

This course is being pursued by Inco's high temperature engineers working in the field and in laboratories at Bayonne, N. J. and Huntington, W. Va. Creep and rupture tests at temperatures as high as 2100 F have supplied data on the strength properties of high nickel alloys. Corrosive attack by various hot atmospheres, fused salts and molten metals is being studied principally in the field to provide the type of information that will assist industry to select more suitable, longer lasting materials for various high temperature applications.

Effects of Carburization

Carburization—as may result from contact with carbonaceous atmospheres in petro-chemical or petroleum refining operations or during the heat treatment of steel parts—is one type of high temperature reaction which, under certain conditions, can change the properties of heat resistant alloys and adversely affect their performance.

Carbon diffuses into the metal and subsequently precipitates as a carbide particle rich in chromium. Compared to the alloy matrix, the carbide phase is hard and brittle. If distributed throughout grain boundaries, the particles provide a continuous path for brittle failure. (See micrograph below.) In certain types of service, carburization of a heat-resisting alloy may not be a serious matter. But in the usual case where the metal part or structure may be called upon to exhibit some measure of ductility or be subjected to impact or to drastic temperature changes, carburization often leads to premature failure.

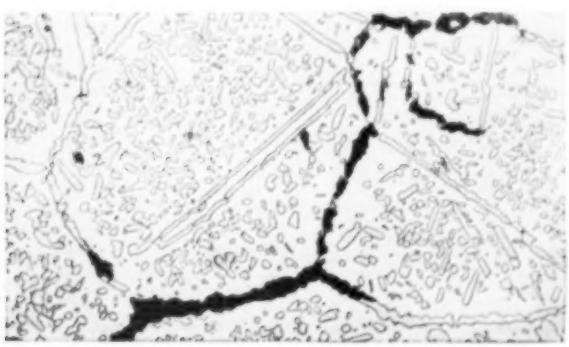
Nickel Plays Basic Role

In general terms, the susceptibility of iron-chromium-nickel alloys to carburization seems to depend upon the relative amounts of the individual components — but not as one might expect. Iron and chromium form stable carbides, while nickel does not. Yet Inco test data show that chromium has a greater effect than either iron or nickel. But it has also been demonstrated that for a given amount of chromium its beneficial effect is much greater at a higher nickel level than at a lower. Conversely, for given nickel content it would be expected that an alloy containing a higher chromium content would be more resistant to carburization.

Assistance Available

Inco high temperature corrosion test data also suggest that silicon improves carburization resistance, as does the presence of carbide stabilizing elements, such as titanium and columbium. Under extremely severe conditions of carburization, the effect of these elements is but temporary, and after sufficiently long exposure, their value is lost.

In a fast growing field such as this, it is impossible to have an immediate answer to every problem. But if high temperature performance is a problem to you, whether in present activities or in new projects, Inco High Temperature Engineers will do their best to help you. Let them send you the High Temperature Work Sheet . . . it is a big aid in getting the facts down clearly. Send for a copy now.



INCO

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Please send me the High Temperature Work Sheet so that I may outline my problem to you.

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Title_____

Company_____

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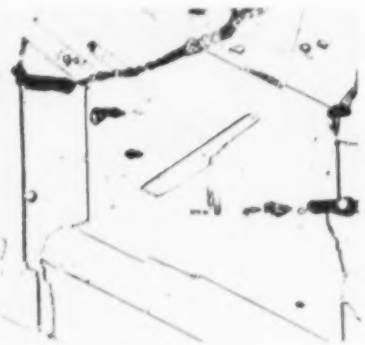
Structure Vs. Corrosion Rate for Type 304L Stainless

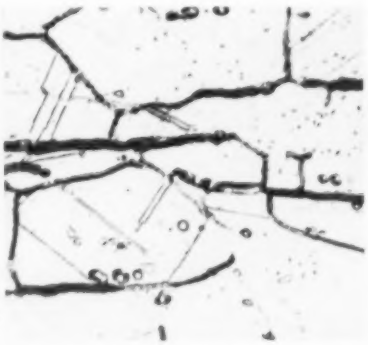
By J. H. Scott, Chief Chemist, Lukens Steel Co., Coatesville, Pa.

The rating system shown is used to predict whether plates of Type 304 L stainless steel will have less than the specified corrosion rate of 0.0020 in. per month after 240-hr. exposure to boiling nitric acid.

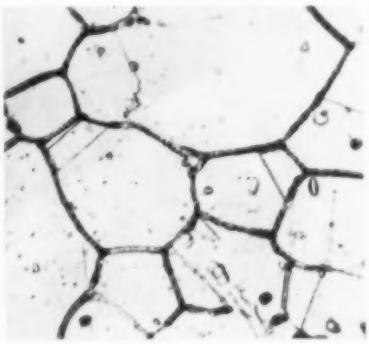
Samples are electrolytically etched in oxalic acid and examined at 350 ×. Rating is based on amount of grain-boundary etching, grain size and thickness of the plate.



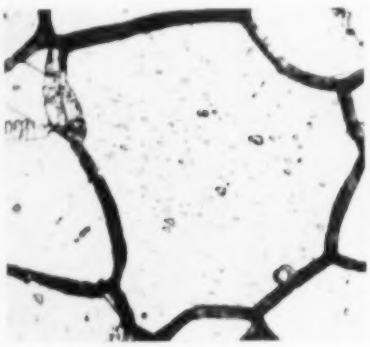
Dual Structure
Rating — Pass
Corrosion Rate — 0.00071 ipm.



Dual structure with light pitting
Rating — Pass
Corrosion Rate — 0.00086 ipm.

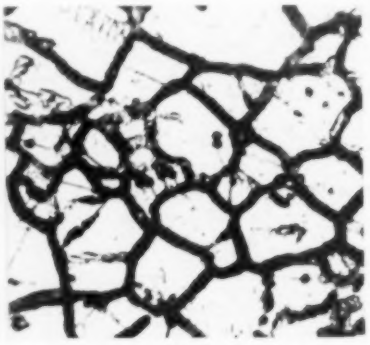


Lightly ditched structure
Rating — Pass
Corrosion Rate — 0.00082 ipm.

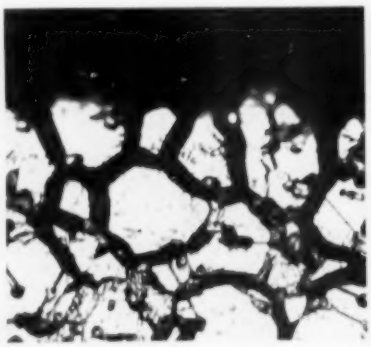


Heavily ditched structure;
coarse grain size
Rating — Pass
Corrosion Rate — 0.00120 ipm.

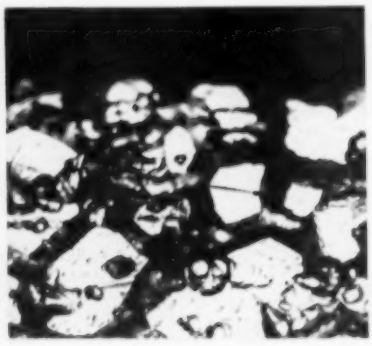
Heavily ditched structure;
medium grain size
Rating — Pass, if under ½ in. thick;
Questionable, if ½ in. thick or over
Corrosion Rate — 0.00116 ipm.



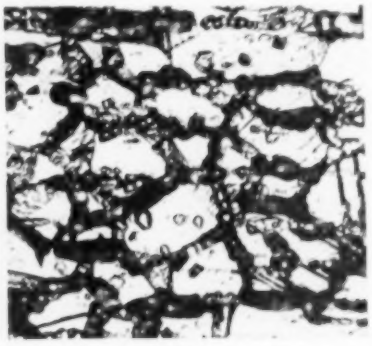
Heavily ditched structure;
fine grain size
Rating — Questionable
Corrosion Rate — 0.00184 ipm.



Heavily ditched structure at surface
Rating — Questionable, unless structure
is not more than 3 grains deep
and thickness ⅜ in. or more
Corrosion Rate — 0.00142 ipm.



Very heavily ditched structure;
fine grain size at surface
Rating — Questionable, if ⅜ in. thick
or more; fail, if under ⅜ in.
Corrosion Rate — 0.00224 ipm.



Very heavily ditched structure;
fine grain size
Rating — Fail
Corrosion Rate — 0.00271 ipm.

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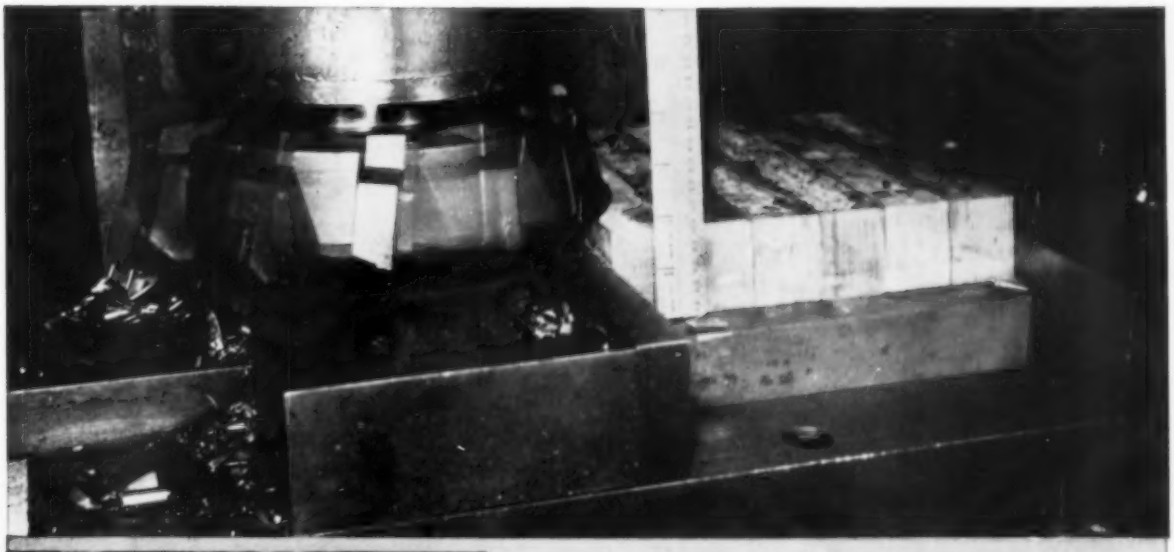

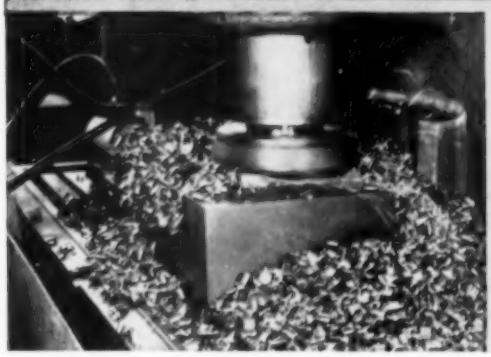

DETAILS OF JOB ILLUSTRATED

Machine	**Sundstrand Rigid Mill**
Cutter Size	**10" Diameter**
No. of Teeth	**12**
Carbide Inserts (grade)	**Carmet CA-610**
Rate of Travel	**400 S.F.P.M.**
Table Speed	**10 in. per minute**
Depth of Cut	**½ inch**
Material	**1095 Cold Drawn Shank Steel, 200 Brinell**

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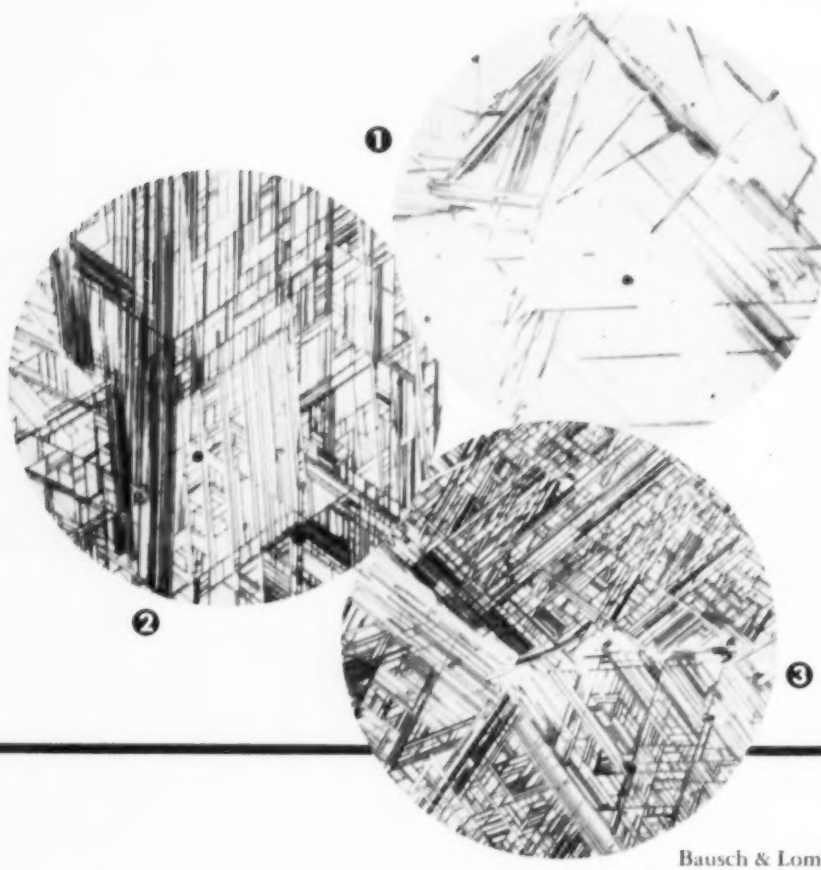

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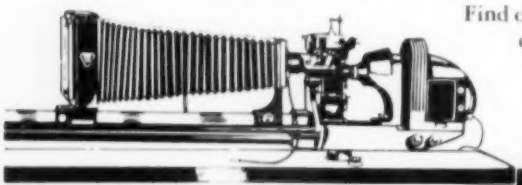

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SINCE B&L 1853

Reduction of Uranium With Magnesium

*By H. A. WILHELM**

First description of the process and equipment whereby thousands of tons of uranium metal of extraordinary purity have been produced to fuel the Atomic Energy Commission's reactors producing plutonium and heat. (C 26, U)

EDITOR'S INTRODUCTION – Prior to World War II it was known that uranium fission is caused by free neutrons and releases extraordinarily large amounts of energy, and that in the process extra neutrons are set free which theoretically could self-perpetuate a chain reaction. To demonstrate the actuality (as was done by the Metallurgical Laboratory at the University of Chicago on Dec. 2, 1942) many tons of highly purified uranium were required. Only a year previous to that date the only metal in America was a few grams of 99.9% uranium made at Westinghouse Electric Corp. by the electrolysis of KUF_5 by a method devised in 1930 by Driggs and Lilliendahl (see *Metal Progress*, April 1948, p. 515). It cost about $1000 per lb. A few pounds of quite impure pyrophoric powdered uranium was also available from Metal Hydrides Co. Intensive chemical work in 1942 solved the problem of extracting uranium from low-grade ore and the production of pure UF_4. It was found that this fluoride could be substituted for the KUF_5 in the electrolytic process, and in this way Westinghouse made more than 6000 lb. of acceptable uranium in 1942 and the cost dropped from $1000 to $22 per lb.

*Associate Director, Ames Laboratory, U.S. Atomic Energy Commission, Ames, Iowa. This is a briefed version of Paper No. 817 ("The Preparation of Uranium Metal by the Reduction of Uranium Tetrafluoride With Magnesium") presented to the United Nations' conference at Geneva. It is based on researches connected with the development of the Ames process for producing metallic uranium. The author wishes to emphasize that this work was a joint effort of many scientists and technicians. The program was directed by F. H. Spedding, W. H. Keller, C. F. Gray and the author.

Quoting from the so-called Smyth Report: "Neither the Westinghouse process nor the Metal Hydrides process was entirely satisfactory. Intensive activity designed to accelerate metal production, and carried out independently by F. H. Spedding and his associates at Iowa State College at Ames, Iowa, and by C. J. Rodden at the National Bureau of Standards, resulted in the development of a satisfactory method. Production facilities were set up at Ames in the fall of 1942 and had already produced more than one ton by the end of November." The process employed at this early date involved the now well-publicized reduction of uranium tetrafluoride with calcium metal.†

(From here on the wordage is taken or adapted from Dr. Wilhelm's Geneva paper.)

A few tons of uranium was produced in the chemistry laboratories of Iowa State College by the bomb reduction of UF_4 with calcium while a small production plant was being set up on the campus. Magnesium was found to be a better reagent and was used exclusively after early 1943. The operations served not only to supply metal for experiments and for charging atomic piles but also served as a pilot plant where men from industries could plan other production plants. Over 1000 tons of billets were shipped from the small building on the college campus before the process was turned over entirely to industry.

Magnesium has these advantages over commercially distilled calcium for the reduction of uranium tetrafluoride: It is freer from elements which might contaminate the uranium. Only 60% of the weight is needed, and the magnesium costs from one-fifth to one-tenth as much as calcium. Magnesium is far more plentiful.

On the other hand, the reaction between UF_4 and calcium generates so much heat that, once started in a mixture at room temperature, it goes forward rapidly through the entire charge. Even if performed in an open vessel, little calcium is lost by vaporization. On the other hand, the heat of the UF_4-Mg reaction is not adequate to fuse the products so metal can separate from the MgF_2 slag. This means that the mixed raw materials must be heated. The heat so added before ignition, plus the heat of exothermic reaction, gives molten metal and slag which readily separate due to their large differences in specific gravity. The boiling of magnesium metal is well below the melting point of the slag, so the operation is most conveniently performed in a closed container or "bomb". The pressure generated also tends to drive the chemical reaction

$$UF_4 + 2Mg \rightleftarrows U + 2MgF_2$$

from left to right.

†See article in *Chemical Engineering Progress*, May 1954, p. 230.

The Reaction Bombs

Early reaction vessels were 4-in. pipe, 6 to 12 in. long. As work progressed, we used standard seamless tubing from 6 to 13 in. inside diameter, and from 36 to 45 in. long as the diameters increased. One end was welded shut with a circular steel plate. A companion flange and bolted-on blind flange closed the other end. Such a crucible was referred to as a "bomb". Only a few experimental reductions were made in the 4-in. bombs; then the size was stepped up cautiously. A rather large tonnage of metal was produced by reductions in 6 × 36-in. bombs.

The regulus of massive uranium produced in a bomb was called a "biscuit". Biscuits were obtained in good yields from charges containing 56 lb. of UF_4 in the 6-in. bombs, 180 lb. of UF_4 in the 10-in. bombs and 318 lb. of UF_4 in the 13-in. bombs. An average of 98.3% yield of biscuit metal was produced in the 13-in. after determin-

Fig. 1 – Mandrel Has Been Placed Inside Steel Pipe Crucible and Fine Refractory Is Being Added to Annular Space While Assembly Is Jolted

ing their proper operating conditions, and the smaller ones yielded about 98% under favorable conditions. Since our plant grew up from a laboratory scale it was not mechanized for handling the large biscuits, so general production was limited to bombs not larger than 10-in. diameter.

Lining the Bomb – To prevent interaction between the charge and the steel bomb, finely ground refractory material is used as a liner. Since contamination of the uranium and failure of the bomb must be avoided, the liner material and the lining operation are very important.

The lining operation starts with placing the empty bomb crucible on an air-operated jolting table. Sufficient powdered refractory is put into the crucible to form a layer about 1 in. thick on the bottom. This is jolted for a few minutes and a mandrel (metal tubing closed at the ends) is lowered into the crucible and rests on this bottom liner. The mandrels for the larger crucibles are an inch or so less in diameter at the bottom than the inside diameter of the crucibles, and they are tapered slightly. The mandrel is centered and then more refractory material poured into the annular space. This loose powder is jolted down and more is added (Fig. 1) until filled. The top region is further rammed by a weighted metal cylinder that fits in the annular space at the top.

During jolting the mandrel must be kept in proper position, not only to produce uniform wall thickness but also to prevent it from sinking and thus producing a thin liner on the bottom. The mandrel has a small plug that fits flush on the bottom face of the mandrel. This plug is attached to a rod reaching up out the top of the mandrel. Removal of this plug allows air to enter at the bottom as the mandrel is slowly and carefully removed from the lined crucible (Fig. 2). A properly lined crucible will have a lining that is strong and difficult to impress with the fingers, as shown in Fig. 3.

Charging – The charge is finely ground UF_4 and granular magnesium, thoroughly mixed. This is emptied into the crucible through a funnel, and rammed down with care (Fig. 4) so as not to disturb the liner. The charge should fill the crucible to about 3 in. from the top.

A thick graphite disk or cake, slightly larger in diameter than the cavity, is then forced down on top of the charge (Fig. 5). The top section of the liner above the charge is then reworked and packed by hand, and the graphite disk covered and struck off flush with the flange. The machined face of a blind flange is then bolted down (Fig. 6). No gasket is used. The charged bomb is then transferred to a furnace or heat soaking pit to initiate the reaction or to fire.

Fig. 2 – Removing Mandrel From Lined Crucible (Mostly Below Floor Level)

Fig. 3 – Looking Down Into Crucible After It Has Been Lined

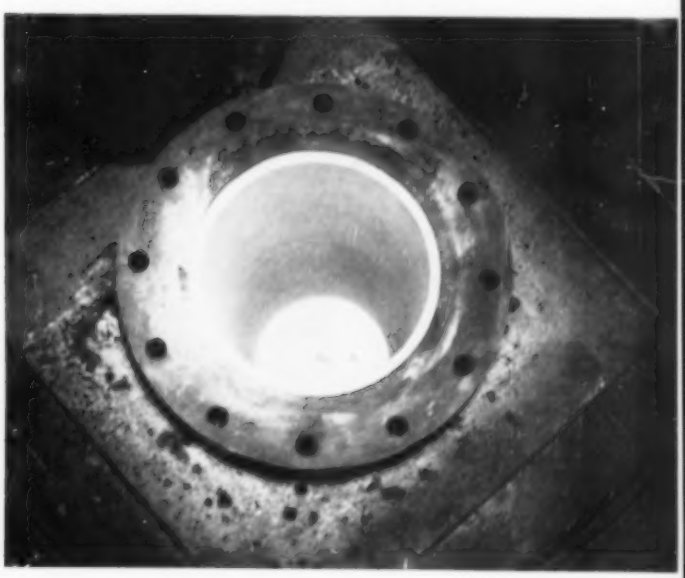


Fig. 4 — Funnel for Adding Charge, a Mixture of Uranium Tetrafluoride and Magnesium

Furnacing

One design of a furnace that serves quite well is shown in Fig. 7. It is gas fired with top at floor level. Such a furnace may extend to almost any length. Only one bomb is shown in position.

Temperature for best operation will depend on size of bomb, rate of furnace recovery on introduction of a cold bomb, control point, and other factors associated with the bomb lining and charge. The optimum temperature will generally be within the range of 1025 to 1300° F. (550 to 700° C.) with the thermocouples located as in Fig. 7. The time required for the reaction to initiate will usually be longer, the larger the bomb and the lower the furnace temperature. Relationships are shown in Fig. 8.

When the reaction starts the bomb is sufficiently agitated for a contact microphone on the end of the reaction indicator rod shown in Fig. 7 to indicate the event. After a minute the reaction is completed and the entire metal phase may remain molten for at least 10 min. in the larger sizes of bombs.

After the reaction has subsided the bomb is removed from the furnace and cooled in air until its temperature is near that of boiling water. It is then sprayed with cold water until its contents are near room temperature. The cover plate is then removed

Fig. 5 — Covering Jolted and Rammed Charge With a Thick Graphite Cake

Fig. 6 — Layer of Refractory Separates Graphite Cover and Top Closure

and the bomb inverted on a jolting table to remove the metal biscuit, the slag and liner.

Adhering slag is then broken or chipped loose and the cleaned metal weighed and delivered to the casting room. The crucible is cleaned and returned to the loading line for installation of another liner and new charge.

Quality of Materials

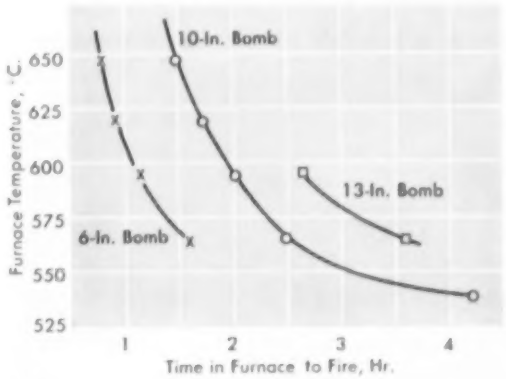
Green Salt – Yields by the above process are quite sensitive to the quality of the raw materials. For example, the yield (percentage recovery of metallic uranium) is higher as the quality of the green salt (UF_4) increases; 98% UH_4 content is to be preferred over 96%. Moisture is damaging, not only for its side reactions but it may create dangerous internal gas pressures. Oxygen (from unreduced UO_3 in the UO_2 from which the green salt is ordinarily prepared, or from other sources) should also be limited. The higher the oxygen content, the lower the UF_4 content and, other things being equal, the lower the biscuit metal yield and poorer the slag separation.

Packing density is important; the higher the packing density, the greater the charge that can be placed in the bomb, and the greater the amount of heat developed per unit area of container wall, and the higher the heat conductivity with correspondingly greater heat penetration into the charge before the surface reaches ignition temperature. Green salt made by the dry process may have a packing density of 3.5 g. per cc. or greater, while wet-process salt may have only half of this. For good yields, 3.0 g. per cc. is desired.

Fineness of grind and particle size distribution also affect the bomb reduction with magnesium, but this can vary over rather wide limits. Good yields come from green salt of which 52 to 62% passes 325-mesh sieve, 62 to 75% passes 200-mesh, 85 to 92% through 100-mesh.

Liner material should obviously be very low in materials which may be picked up by the biscuit metal during the vigorous reduction reaction. Dead burned, high-calcium lime and electrically fused dolomitic oxide were successfully employed when the final refractory contained

Fig. 8 – Variation of Firing Time With Furnace Temperature. Inside dimensions of unlined cylindrical bomb casing are noted



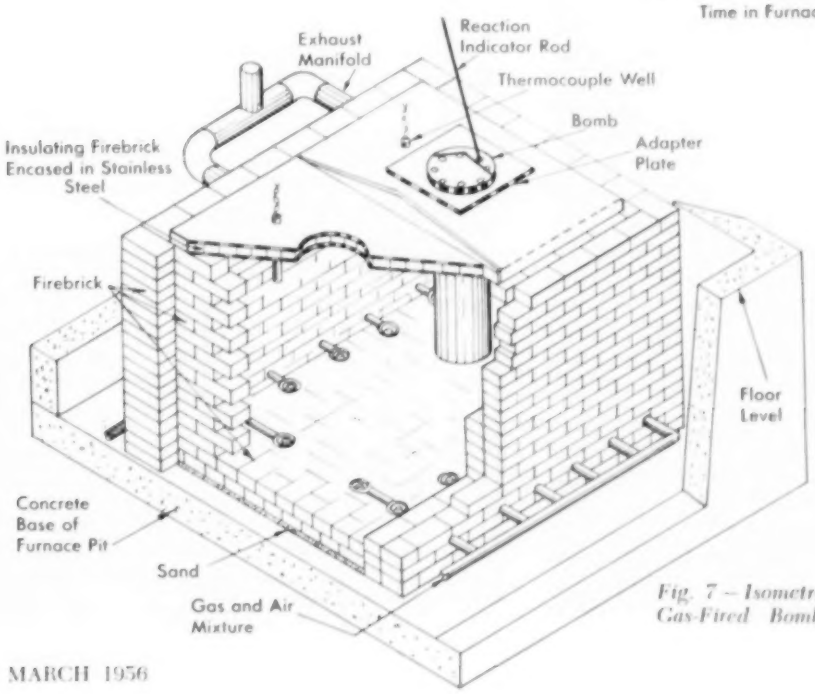


Fig. 7 – Isometric View of Gas-Fired Bomb Furnace

about 500 ppm. iron, 60 ppm. manganese and 5 to 10 ppm. boron. As with green salt, the burned refractory should be prevented from absorbing moisture. Loss of weight by ignition should be low; this could be kept below 0.25% with the dolomitic oxide and this made it the preferred refractory.

When moisture is evolved from the refractory during heating a thin layer of UO_2 is formed next to the liner and this is not reduced to metal. To avoid this loss a little fine magnesium or calcium metal is added to the refractory mixture, which reacts with the moisture forming hydrogen gas, which in small amounts is not harmful.

Packing density of the ground refractory also affects the quality of the liner. The greater the degree of fusion of the magnesium-calcium oxide from the dolomite, the less H_2O and CO_2 it will later absorb, and the higher the packing density. While ordinary burned lime and dolomitic lime have packing densities of about 1.45 and 1.35 g. per cc. respectively, successful bomb liners should have densities of 1.75 for lime and 2 g. per cc. for fused dolomite.

Average sieve analyses for electrically fused dolomitic oxide are 40% through 325 mesh, 53% through 170 mesh, 78% through 80 mesh, 98% through 45 mesh.

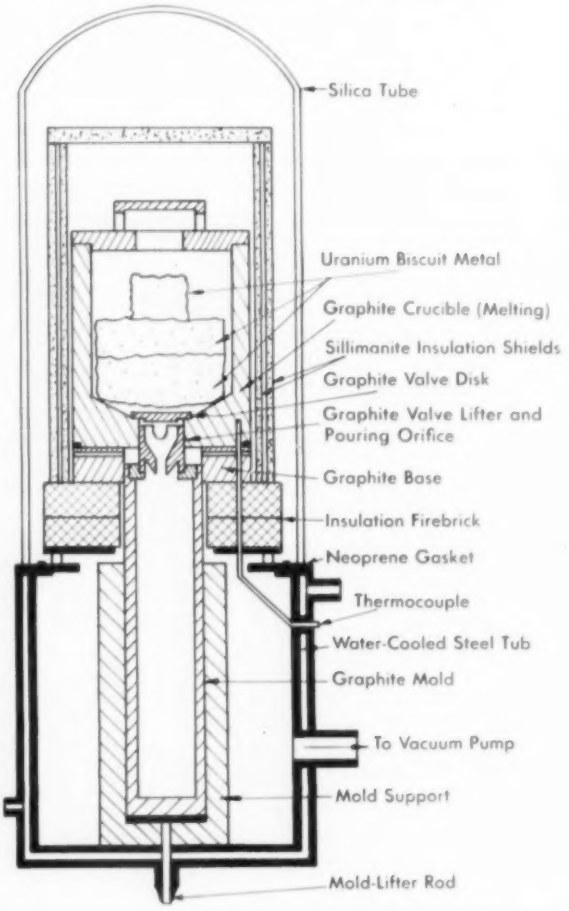
Magnesium – In the early work, there appeared to be wide variations in the reduction behavior of various lots of magnesium, even though all met the chemical requirements for purity. Observable differences in crystal shape and in flake or particle shape hardly seemed responsible. Operating variations in the magnesium plant – such as temperature of metal when withdrawn from the retort, or air leaks into the vacuum system – might have been responsible. At any rate, better results were obtained, on the average, with magnesium from a plant employing the ferrosilicon process, and we therefore standardized on this one source.

This magnesium came in the form of hollow cylinders, or muffs, about 10 in. in diameter. They were formed on the condenser walls as the matted and finger-like crystals grew from the magnesium vapors. The crystal orientation was somewhat radial with little tendency for the crystals to grow together. The muffs were readily broken with a sledge hammer, and the pieces were cut to hand size on a punch press fitted with cutter blades. These chunks were passed over a magnetic separator to remove any tramp iron, and reduced to ¾-in. pieces in a standard cutter-type mill used in shredding wood and paper and often referred to as a "garbage hog". The cutting was done by heavy knives mounted in the face of a heavy rotor; the knives passed within a fraction of an inch of heavy metal bars. With the rotor operating at high speed, the chunks of magnesium were readily cut to pass through a screen in the bottom of the mill.

After another magnetic separator the next machine contained a number of long knives mounted on the outer edge of an open-framework reel that rotated on an axis. The rotating knives passed within a few thousandths of an inch of a number of stationary knives mounted in the housing. This machine, except for its screens, was a standard mill used for chopping-up corn and other grain.

Fines and dust were then screened out, and the remaining magnesium was sampled and passed over a third magnetic separator. The particle size distribution was as follows: 90 to 99% through

Fig. 9 – Unit for Casting Uranium Ingots in Vacuum (Not Drawn to Scale). Induction coil, giving heat to graphite melting crucible, is shown in Fig. 10



No. 10, 25 to 55% through No. 20, 10 to 35% through No. 30, 3 to 15% through No. 40.

The magnesium was ground as needed, to avoid possible oxidation from the air on standing.

Operational Considerations

Some excess of magnesium over stoichiometric ratio is necessary for a good yield of uranium in the bomb reaction. Large bombs (10 in. and larger) need about 5% excess; 6-in. bombs 7%.

Liners must be thick enough to protect the steel casing, yet not too thick to hamper the flow of heat during firing and cooling cycles. We found that ½, ⅝ and ¾-in. walls of fused dolomite were sufficient near the bottom for the 6, 10 and 13-in. bombs respectively. Wall thickness at the top, due to tapered mandrels, was slightly less. A batch blender of the double-cone type was satisfactory for mixing the weighed amounts of green salt and fine magnesium. Thorough mixing is essential.

Since the internal pressure is high during the bomb reaction, operators must be protected from possible bomb failure. The concrete pit shown in Fig. 7, with additional brick walls around the furnace was found quite adequate. Operators should not remove any fired bomb from a furnace until the reaction has fully subsided. Hot spots may develop on the bomb areas having partial liner failure; complete failure of the liner at a point would result in a blow-out.

The furnace design can vary widely as long as the temperature is uniform. Any fuel may be used. Time in the furnace is shown in Fig. 8; the higher temperatures that shorten the soaking time may or may not be advantageous from the standpoints of yield of metal and furnace life.

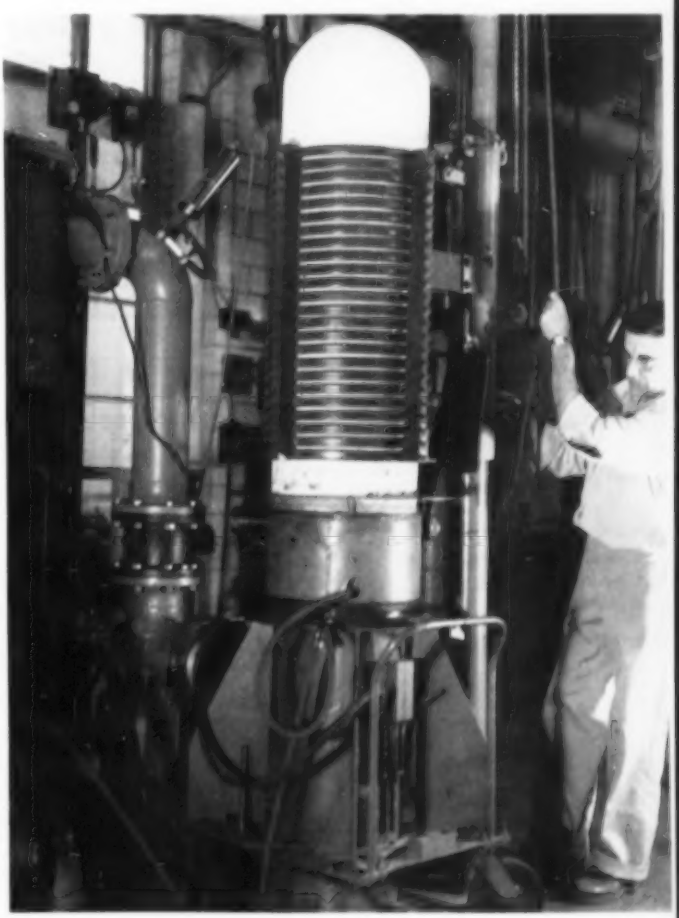
Another factor is relation of furnace temperature and yield. In a series of tests where the only planned variables were diameter of bomb, age of ground magnesium, and furnace temperature, the biscuit yields showed consistent maximums at or near 1095° F. (590° C.). While these results have no great generality, they indicate that to be reasonably sure of getting the best yields with the materials and equipment available, proper furnacing conditions should be established. These tests may also include a standard casting operation and be based not on biscuit yields but on over-all yields of final cast metal.

Casting Uranium Metal

Early in 1942 small castings of uranium metal were made in a vacuum furnace. Uranium powder compacts supported in beryllia crucibles were heated by high-frequency electrical induction. At high temperatures the liquid uranium would break through its tough oxide skin and flow through a grill and into a beryllia mold. Experimental work at Ames soon demonstrated that graphite crucibles were satisfactory for vacuum induction melting. The melting point of uranium was found to be about 2065° F. (1130° C.) and at pouring temperatures of up to 2400° F. (1300° C.) and even higher, the solubility of carbon in uranium was only a few hundred parts per million. In the early production plant, uranium was melted in a graphite crucible having a grill for the bottom to catch oxide skins as the metal flowed into a heated graphite mold below.

In certain phases of uranium metallurgy there may develop concentrations of materials that present hazards to health. Vacuum melting and

Fig. 10 – Adjusting Position of Induction Coil Preparatory to Melting Uranium Biscuit in Device Sketched in Fig. 9



casting does give some concentration of such materials, especially in the flue dust and in the dross from graphite crucibles.

Pouring temperature and rate of flow in the early set-up were uncertain and had to be replaced by melting and casting units that would give better control and larger ingots. The designs were modified from time to time as sizes and shapes of castings were changed.

One design for vacuum casting a single ingot is shown in Fig. 9. The heating is by an external induction coil (shown in Fig. 10) which is lowered around the silica tube. Heat is generated in the graphite crucible and its temperature is followed by the thermocouple. At casting temperature the disk in the crucible bottom is opened by an upward thrust on the mold-lifter rod. The valve disk is forced up from its seat and floats to the top of the melt as the liquid uranium flows through the orifice and down into the mold. The mold cavity is ventilated through ports (not shown) in the valve lifter below the orifice.

The ingot obtained by this process is cropped to remove the pipe and the resulting billet is an intermediate form for further fabrication into shapes.

Rod Casting – A furnace of essentially the same design was set up early in the development work to cast charges of about 300 lb. of uranium into nine rods about 1½ in. diameter by 29 in. long. The mold chamber of Fig. 9 contained nine appropriate molds, nested together, whose top ends were centered under as many holes in a tun disk, placed between them in the bottom of the crucible. All rods were cast simultaneously.

Direct pouring is possible if the bottom of the reduction bomb is shaped as shown in the top part of Fig. 11.

The charged bomb is placed in the furnace and a few minutes after it has fired, the hot bomb is placed over the graphite mold assembly held rigidly together by turnbuckles. The ball face of the valve spout fits into a cone in the top face of a graphite cover to the mold. In bringing the two together sufficient pressure is exerted to force the valve spout up in the valve housing, thus permitting the molten metal to flow through the spout to the mold.

Bomb charges containing 318 lb. of green salt gave about 238 lb. of metal for each such casting. The ingots when cropped below the pipe gave billets weighing about 220 lb. Ingots produced by this process are exceedingly low in carbon content but are higher in magnesium and hydrogen than metal melted and cast in vacuum as described in the earlier paragraphs.

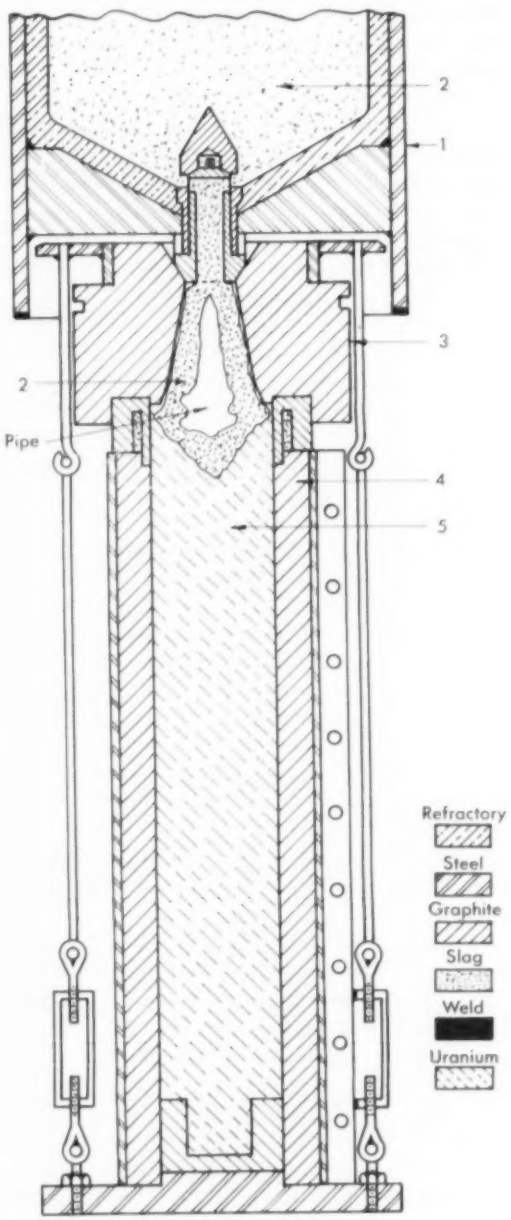


Fig. 11 – Scheme for Casting Uranium Ingot Directly After Reduction in Bomb With Specially Designed Bottom

Legend: 1. Lower end of bomb
2. Magnesium fluoride slag
3. Mold cover and entrance spout
4. Mold.
5. Uranium ingot

Superconductivity

*By A. WEXLER**

One of the most interesting phenomena discovered in low-temperature research is the superconductivity found in a few elements and compounds. Electrical resistance decreases to an immeasurably small value and the material becomes perfectly diamagnetic. Unfortunately the highest temperature at which superconductivity is found is 18° K., about – 430° F. (P 15)

In the frigid areas of northern Siberia, the temperature once dipped to −90° F., the lowest atmospheric temperature ever recorded officially on the earth's surface. To most people, this is an almost inconceivably low temperature. To the specialist in that field of research, however, "low temperature" is a range far removed from even the most unusual atmospheric conditions. His area of investigation begins several hundred degrees lower and ranges down to within a few tenths of a degree of −459° F., or absolute zero.

Low-temperature research is a scientific and an engineering field of considerable and growing activity. Before the war this field was investigated at perhaps a half-dozen laboratories, mostly in Europe; today the number of laboratories is about 100, most of them in the United States.

Why has the low-temperature field continued to attract a growing number of scientists and engineers? Answers to this question involve the theoretical significance of low-temperature research as well as the discoveries that already have been made in this field.

In the first place, low-temperature research opens up for exploration a literally limitless temperature range. In a given temperature range the abundance of new phenomena depends not on the number of degrees of temperature involved but rather on the ratio of the absolute temperatures covered. From this point of view, a more realistic picture of the importance of a given temperature interval is given by considering the logarithm of the absolute temperatures; the infinite extent of the low-temperature field then becomes apparent. More specifically, with simple liquid-helium techniques a temperature of 1° K. can be reached quite easily – a temperature which is 1/300 of room temperature. To increase the absolute temperature by a factor of 300 upward from room temperature would involve a temperature of 90,000° K.

In the second place, the power of low-temperature research lies in the effects of lowering the thermal energy of substances. Thermal energy is simply the energy a substance has by virtue of its temperature. Lowering the temperature greatly simplifies the physical processes that occur within a substance, so low-temperature experimentation is a general tool for studying the electrical, magnetic, optical, thermal and mechanical properties of substances.

One way by which this simplification occurs is through the reduction of the thermal agitation of the atoms comprising a substance; this often makes possible studies that would be exceedingly difficult, if not impossible, at high temperatures. For example, the role played by impurities in determining the electrical and thermal conductivities of metals is often masked at higher temperatures by the violently moving atoms, which, in colliding with the electrons, absorb most of the energy lost by them in passing through a metal. Lowering the temperature brings this atomic dance almost to a halt, and the effects of the impurities as well as those of boundaries of the conductor can be observed.

Another example of great importance for the theory of metals is provided by a consideration of the specific heat of a metal – that is, the ratio of heat energy absorbed to the change in tem-

*Manager, Magnetics and Solid States Physics Dept., Westinghouse Electric Research Laboratories, Pittsburgh.

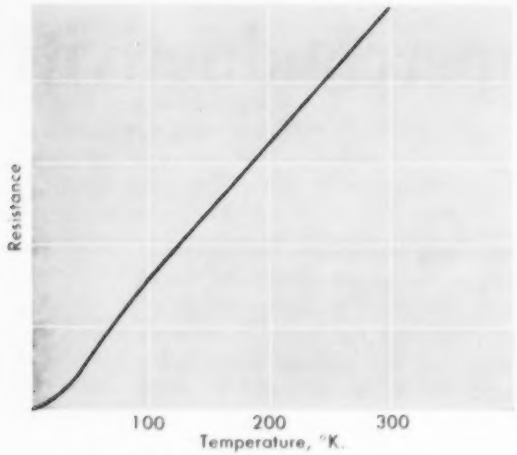


Fig. 1 – Effect of Temperature on the Electrical Resistance of a Pure Metal

perature. To understand the metallic state, the contribution to the specific heat by the electrons must be known. Only in the liquid helium range can the masking effects of the specific heat of the atoms be eliminated, and that of the electrons be made to stand out. To summarize, the obscuring effects of thermal agitation can be eliminated at low temperatures, and individual fundamental processes, hidden at high temperatures, can be sorted out and studied in relative isolation.

In the third place, the study of the temperature dependence of some property over a temperature range involving a large ratio of absolute temperatures often provides an insight to the processes underlying the property. For example, the study of the magnetic susceptibility of phosphors from room temperature down to 1° K. has shed considerable light on the nature of activators – the impurities present in minute amounts on whose presence the effectiveness of the phosphor depends.

Thus, low-temperature techniques provide a unique and powerful tool for scientific studies – a tool which, like X-rays, has become essential for experimentation in diverse areas of physics, metallurgy, chemistry and engineering.

There is yet another aspect of the lowering of thermal energy. Suppose that phenomena exist in nature that are so delicate that the thermal energy present in materials at ordinary temperatures prevents their appearance. The most striking example of such a phenomenon is superconductivity. A large number of metals and alloys, at temperatures below a certain transition tempera-

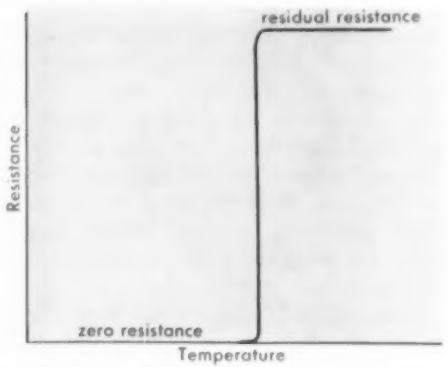
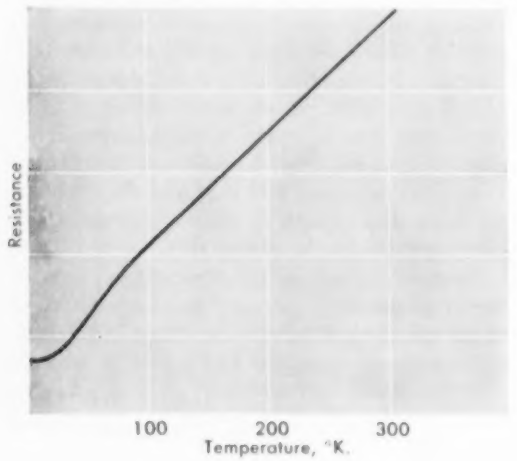


Fig. 3 – Change in Electrical Resistance of a Superconductor at Temperatures Near Absolute Zero

ture characteristic of each substance, completely lose their electrical resistance and, while in this superconducting state, are perfectly diamagnetic. In sharp contrast to superconductivity is the rise in electrical resistance at low temperatures, another baffling low-temperature phenomenon exhibited by a number of slightly impure metals. At low temperatures liquid helium itself undergoes changes in properties that in many respects are as spectacular as those shown by superconductors. It becomes "superfluid" and flows rapidly through the smallest openings. Its thermal conductivity also increases enormously, making it a better heat conductor than the purest metal.

At the temperature of liquid helium all other substances are solid, and oxygen and nitrogen resemble white sand at ordinary temperatures. The strength of low-carbon steel increases by a factor of five over that at room temperature but

Fig. 2 – Effect of Temperature on the Electrical Resistance of an Impure Metal



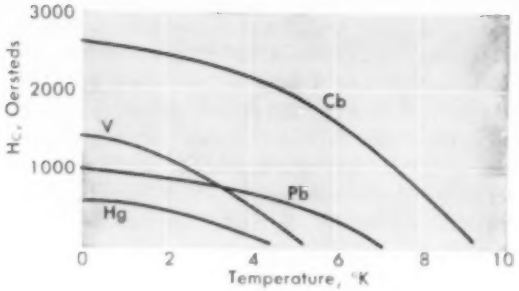


Fig. 4 – Critical Magnetic Fields of Some Superconductor Metals

it becomes quite brittle. Certain dielectric materials have thermal conductivities at these temperatures as much as 60 times greater than that of copper at ordinary temperatures. The metal gadolinium, whose magnetic properties at ordinary temperatures are not unusual, is ferromagnetic at low temperatures with a saturation magnetization per unit mass 16% greater than that of iron.

Uses of Superconductors

Of the low-temperature phenomena mentioned, superconductivity is perhaps the most interesting, both from a fundamental viewpoint and from the standpoint of possible usefulness to the electrical industry. When the temperature of a metal is decreased, its electrical resistance is lowered. Why this should happen is easy to see in a rough way. The carriers of electrical current – the electrons – collide with the atoms comprising the metal and give up to the atomic lattice some of the energy acquired by the electrons from the electric field. This transferred energy is, of course, the Joule heat loss. According to theory, an electron passing through a perfect lattice would lose no energy. The thermal motion of the atoms destroys the perfection of the lattice, and an ideal metal would be expected to have a resistance temperature characteristic as indicated in Fig. 1. Actually, the electrical resistance of a metal does not go to zero as absolute zero is approached because there are imperfections due to chemical impurities and to physical imperfections of the metal structure. At low temperatures, where the scattering of electrons by the thermal motion of the atoms makes a negligible contribution to the resistance, the electrical resistance of a metal assumes a temperature-independent value, called the residual resistance, which is a measure of the level of chemical and physical impurities, as shown in Fig. 2.

This was the state of knowledge when, in 1911, three years after he had succeeded in liquefying helium, the Dutch physicist, Kamerlingh Onnes, discovered in mercury the first example of the complete disappearance of electrical resistance. His completely unexpected discovery is illustrated in Fig. 3. He observed that the resistance suddenly became immeasurably small as the temperature was lowered below a characteristic transition temperature, 4.15° K.

After more than 40 years of experimental and theoretical study, a great deal is known about the properties of superconductors, and more superconductors are continually found. Yet the phenomenon has eluded an explanation based on first principles; it ranks with the nature of nuclear forces as one of the major problems facing the theoretical physicist.

What are the important properties of superconductors? It has been found experimentally that to every temperature below the transition temperature there corresponds a value of the magnetic field that destroys superconductivity, and restores the normal resistance. Figure 4 sketches the critical field and temperature relation for a number of superconductors.

From the standpoint of certain possible applications – for example, as resistance-less winding in transformers – it is unfortunate that nature has imposed these limitations of magnetic field. The maximum field in which superconductivity can be maintained in a pure metal is 2600 oersteds for columbium.*

The magnetic properties of a superconductor, like the electrical ones, are unique. From electromagnetic theory one would predict that once a material is in the superconducting state, a mag-

*The author prefers the term "niobium", but *Metal Progress* style standardizes on the more conventional "columbium".

Comparison of Fixed Points on Various Temperature Scales

	Temperature Scale			
	Fahrenheit	Centigrade	Kelvin	Logarithmic
Absolute zero	−460	−273	0	−∞
Boiling point of helium	−452	−269	4.2	0.62
of hydrogen	−422	−253	20.4	1.31
of oxygen	−298	−183	90.1	1.95
Melting point of ice	32	0	273	2.43

netic field could not enter the bulk of the material because shielding currents would be induced in a thin layer at the surface of the perfect conductor by any applied external field. As long as the critical field, H_c, is not exceeded, the magnetic induction within the material should remain zero. If, however, H_c is exceeded and the field is then reduced below H_c, the induction in the material when it again becomes superconducting should remain "frozen" in. An entirely new phenomenon is actually observed; the magnetic induction of a superconductor is zero and is independent of its magnetic history. This perfect diamagnetism is a totally unexpected property and, like the absence of electrical resistance, remains unexplained to this day.

Of course, an immediate question arises: "Do we really mean that a superconductor has zero resistance?" Experimentally, such resistance can be shown to be no greater than a certain amount; that is, only an upper limit to the resistance can be established. But the upper limit that has been established is very low; below the transition temperature the resistance of a superconductor is no more than 1×10^{-15} of its value at room temperature.

The very low upper limit can be demonstrated quite easily. A ring is made of the material and cooled below the transition temperature. Physically, the ring may be very similar to a wedding ring. It is exposed to a magnetic field in excess of the critical field at that temperature and then the field is reduced to zero. As a result, thousands of amperes may be caused to flow in the ring and, judged from its magnetic effects, this huge current continues to flow for days with no measurable diminution.

More than 20 elements and a large number of intermetallic compounds become superconductors. Curiously enough, the best conductors, copper and silver, are not among them. In fact, a useful trick employed by low-temperature physicists is to copper-plate superconductors when one turn of superconducting wire must be insulated electrically from another. At temperatures near absolute zero, copper of the best purity available has a resistance only one-thousandth of its room-temperature value. Thus, its efficacy as an electrically insulating coating is based not on its absolute resistance, which is quite low, but rather on its resistance relative to that of the superconductor it insulates.

The element with the highest transition temperature (about 11° K.) is technetium; another element with a high transition temperature is lead (7.2° K.). Other metals, such as cadmium, ruthenium and titanium, have transition temperatures within one degree of absolute zero. Incidentally, during the last decade extensive studies have been pursued in a temperature range within a few thousandths of a degree of absolute zero — a range of temperature in which man has surpassed nature by a handsome margin. The highest transition temperature (close to 18° K.) for superconductivity so far observed is for the intermetallic compound Cb_3Sn. The search for high transition temperatures, which could provide important clues to the understanding of superconductivity as well as bring practical application closer to realization, is continuing.

Up to the present time the rich store of low-temperature phenomena has been virtually untapped with respect to commercial applications. While it is not impossible that low-temperature techniques will one day be applied to heavy electrical equipment, the first application will probably come in specialized fields of instrumentation, such as in computers. Here, there is the promise of greatly decreasing the size of complicated equipment by the use of new types of tiny electronic elements.

One example of the use of low-temperature phenomena in special areas of instrumentation is the superconducting bolometer. It is a device used as a detector of radiant energy. A typical bolometer has a minimum detectable energy in a single flash of 2×10^{-6} erg and can be used as an alpha-particle detector which counts the particles and also gives an indication of their energy.

Another example of instrumentation using low-temperature techniques is to be found in liquid helium and liquid hydrogen bubble chambers. Superheated liquid helium and liquid hydrogen have been found to be very sensitive bubble chambers, giving tracks when exposed to ionizing radiation in a manner analogous to that of the more familiar cloud chambers.

The possibility of useful applications of low-temperature phenomena is among the less subtle reasons for the interest of the electrical industry in this field. By now the unity and interdependence of various fields of physical sciences are well appreciated. Research in a pioneer field such as low-temperature physics is of value not only to the specialist in this field but also to those working in related fields. The interactions of scientists, both within a given laboratory and through the normal channels of exchange of scientific information, are essential to the rapid and continuing progress of science.

In the manner of the science fiction writer, predictions could be made here of the marvelous innovations that will result from research in a field which already has revealed such startling electrical and magnetic phenomena. This will be left to the imagination of the reader; the history of science indicates that the actual developments coming from research in pioneer fields generally dwarf in magnitude the predictions made by the most futuristic prophets.

The era of large-scale use of low temperatures in industry has already arrived. In specialized fields, as in gas separation and liquefaction, the applications have been in effect for many years. Low-temperature techniques have played an essential role in thermonuclear developments. Special containers whose temperatures can be maintained within a few degrees of absolute zero for hundreds of days – with practically no attention after initial loading with liquid helium refrigerant – have been developed at the Westinghouse Research Laboratories and are universally used in low-temperature work. Just when low-temperature techniques will be used on a commercial scale is largely in the hands of the scientists and development engineers.

Correspondence . . .

Recent Accidents With Large Forgings

ESSEN, GERMANY

The lengthy report of the failure of four large electrical machines in your February issue takes me back about 25 years in my professional life. In high-pressure steam power plants we had found brittle intergranular failure in creep specimens of heat treated alloy steels. Ten years previously we had come to grips with the problem of flakes in large forgings and their association with hydrogen. A very large amount of work on the latter problem had been summarized in several articles in *Technische Mitteilungen Krupp* between 1935 and 1941.

As to flakes, we have attacked the problem in several ways. First, careful preparation of furnace charge to minimize moisture. Second, rigid control of refining period. Third, adjustment of forging and heat treating cycles according to size of piece and composition of steel. Finally, the new system of vacuum pouring, recently perfected at the Bochumer Verein, sucks off enough hydrogen to save ingots which otherwise might turn out to be flaky.

We believe that the composition of the steel in a large forging has a great deal to do with its integrity. The steel should be one which transforms readily on slow cooling and at a high temperature into a pearlitic microstructure.

Personally, I would avoid steels with nickel up to 3% and with more than 0.35% molybdenum, because they transform in the indicated heat treating cycles mostly in the bainitic if not partly in the martensitic range, and this is not the best for a hydrogen-relieving anneal. Because of these circumstances we believe that the heat treatment of a large forging should be selected according to its metallurgical treatment, mass, shape, and rate of transformation – that is to say, its analysis. Few general statements can therefore be made.

Sometimes the steelmaker is so pressed for delivery that he finds it difficult to allow the proper heat treatment – especially the *very* slow coolings to room temperature. For this reason German manufacturers of large forgings have adopted a policy of holding rough-forged ingots in stock, and forging the final shape to order.

Once a steel is infested with flakes it cannot be reclaimed by any heat treatment known to me without forging. Fracture on test or in service occurs suddenly without any measurable plastic deformation. If this occurs during alternating load, it can technically be called a "fatigue failure", but the fracture spreads so rapidly one can seldom find any "porcelanic" areas, thought to be characteristic of fatigue failures.

Ductility *in sound metal* at high temperature is an entirely different problem. (Your account of the American troubles indicates that two of the failures were steel of deficient ductility.) Here again I refer back to experiences of the past 20 years, wherein we have come to the belief that good creep resistance *and* ductility in creep-rupture tests should be achieved in some other way than by raising the steel's resistance to creep in short-time tests.

We know, of course, that a steel's creep values can be improved by correct heat treatment, but an optimum combination of strength and ductility requires that the steel be in microstructural equilibrium at the temperature of test – supposedly close to the working temperature. The intergranular failures mentioned in the second sentence of this communication seem to be due to changes in carbide composition, and the precipitation of fine carbides, in an "unbalanced" steel composition containing a high molybdenum content. Embrittlement of this sort is not observed if the proper steel receives a final stabilizing heat treatment (tempering) at a somewhat higher temperature and is thus brought into a state of firmer equilibrium at the temperature of service.

EDUARD HOUDREMONT
Consulting Metallurgist

Steel Specifications

HOUSTON, TEX.

I would like to commend Mr. Snyder for the excellent article "Limitations of Steel Specifications" which appeared in the November issue of *Metal Progress*. It is an unusual presentation of a subject of interest to all users of steel. It might be very useful to follow this up with similar articles dealing with other specific instances of inadequacies of specifications.

One recent example that has caused us some concern is the notation added to steel specifications in the A.I.S.I. Manual published July 1955 that limits the chemical analysis table to standard steels of 200 sq.in. or less in cross section. If you buy larger blooms for forging, the chemical variation can be so large that it is virtually impossible to obtain uniform results in processing. The permissible ranges of carbon and manganese content of S.A.E. 1330 now are:

200 SQ.IN. OR LESS	CARBON	MN
Standard range	0.28-0.33	1.60-1.90
Check analysis tolerance	± 0.03	± 0.05
Final range	0.25-0.36	1.65-1.95
201 TO 400 SQ.IN.		
Standard range	0.25-0.35	1.55-1.95
Check analysis tolerance	± 0.04	± 0.06
Final range	0.21-0.39	1.49-2.01

We agree that greater checking tolerances should be allowed on larger blooms but what does bloom size have to do with the chemical composition measured in the ladle? The larger blooms are used to make small forgings that must be heat treated and it is virtually impossible to obtain uniform properties with an alloy whose carbon may vary 0.18% and manganese, 0.52%. Thanks to the good graces of the steel producers, we can specify and obtain a narrower range by paying a price extra.

A committee of representative users of steel should be given the opportunity to study proposed changes in the A.I.S.I. limits before they are adopted. I would be very happy to cooperate with any such group organized to eliminate the present inadequacies of specifications.

W. D. GILDER
Chief Metallurgist
Reed Roller Bit Co.

AURORA, ILL.

I very much appreciate Mr. Gilder's contribution to the problem of excessive spread of steel specifications. Misery loves company, but we *don't* love the misery.

I agree with his complaint about wider *ladle* ranges for alloy steel exceeding 200 sq.in. in cross section. Molten steel taken for a ladle analysis certainly doesn't know whether it is going into large or small products. There appears, therefore, to be little reason for a wider ladle range for steel destined for products of larger cross section.

After solidification, there is more justification for greater composition tolerances. There is more opportunity for segregation in a large ingot mold than a small one and less opportunity for diffusion toward a uniform composition when there are fewer cycles of heating and less relative reduction by rolling. This, however, is taken

care of very neatly by A.I.S.I.'s wider check analysis ranges for larger products. On carbon, for instance, the check analysis tolerances are only ± 0.01% for products up to 100-sq.in. cross section but ± 0.04% for cross sections between 400 and 800 sq.in. With this greater check analysis range, a wider ladle range for larger sections is both unnecessary and unreasonable.

More vigorous and more numerous demands on the steel producers for greater uniformity of composition and other properties are the only avenue to improvement open to most steel consumers. There are a few large fabricators who control a considerable portion of steel-producing facilities required for their own operations and I am of the opinion that they experience less fabricating trouble because of this control.

With passage of time, steelmaking processes do improve; better quality is obtained and closer limits are held. Vacuum casting of steel looks very promising as a means for obtaining superior quality. When we are in trouble, however, progress seems exasperatingly slow.

For Mr. Gilder's immediate problem of heat treating forgings of S.A.E. 1330 steel, he might find it advantageous to change to 1330 H. The composition range will be even wider than is now experienced but less variation will be found in heat treatment and final properties.

E. H. Snyder
Chief Metallurgist, Austin-Western Works
Baldwin-Lima-Hamilton Corp.

Shell Molding

Pittsfield, Mass.

In A. H. Allen's digest of W. H. Dunn's paper "What Does Shell Molding Offer the Producer and User of Castings?" in the September issue of *Metal Progress*, there are several statements that could cause some difficulty.

On p. 214, the statement is made, "smaller risers give better yields and consequently more castings per ton of metal melted". We are of the opinion that this attitude is responsible for a great amount of trouble encountered in shell molding work. While the nature of the material in which the metal is solidified has been changed, the rules for metal shrinkage have not been altered by the shell molding process. The relative cooling rates of the castings, as compared to the risers, are still in the same order. Consequently, the necessary riser feeding for shell molded castings is essentially the same as for other processes. We do agree, however, that greater yields are possible, but through the reduction of runners and ingate sizes, not risers.

On p. 216, it is stated that, ". . . the shell mold acts as a chill and approaches the effect of a permanent mold". In this regard, we agree that under certain unusual circumstances, the above condition may exist. However, in the majority of applications, shell molds are relatively insulating as compared with both green sand and permanent molds.

In the next paragraph, Mr. Allen cites the ability of the process to produce thin walls. This in itself is a confirmation of the increased fluidity of metals poured into shell molds, by a relatively insulating rather than a chilling effect.

Jack E. Bolt
Chemical Materials Department
General Electric Co.

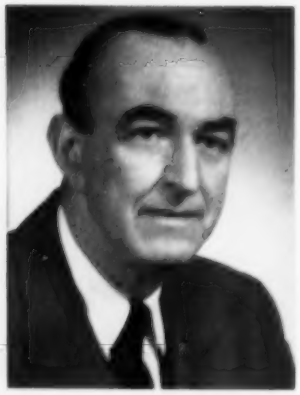
San Diego, Calif.

Regarding the riser size of shell castings as compared to green sand casting, the need for risers and the size of risers required is a function of subheat above liquidus. Obviously, if metal could be poured at its melting temperature no volumetric change would take place and risers would be unnecessary. We are often able to use smaller risers in shells because we are able to pour cooler.

The discussion of shell molds acting as a chill would perhaps be better understood if I explained that our shell molds are made from zirconium silica sand which has a much higher rate of heat conductivity than silicate sand. Mr. Allen cites the ability of shell to produce thinner walls. He believes that the increased insulating effect is responsible. We do not agree. The ability to produce thinner walls is the result of the smoothness and lack of friction offered by shell molds as compared to a regular sand mold. Of course, if you wish to take advantage of the ability to produce thin walls you must pour rather hot and, therefore, lose the advantage of better yield. You cannot have both in the same casting. To summarize, if we pour at the same temperature, we use identical riser size, but are able to pour much thinner walls. If we are not required to produce thin walls we pour much cooler in shell than in sand and are, therefore, able to reduce riser size. It is our belief that both of these are due to the smoothness of the wall of the shell mold.

W. H. Dunn
Vice-President and General Manager
Pacific Alloy Engineering Corp.

Personal Mention



James C. Hodge

Announcement was recently made by Warner & Swasey Co., the well-known Cleveland makers of lathes and other machine tools, that JAMES C. HODGE has been elected vice-president, with the immediate responsibility of studying manufacturing methods in the company's three factories in Cleveland, New Philadelphia, Ohio, and Lansing, Mich.

An immigrant from Scotland as a boy, Jim Hodge received his technical education at Case Institute of Technology and was later awarded a doctorate from the Engineering School of Harvard University. After graduation he worked as metallurgist for 13 years in the research and welding engineering departments of Babcock & Wilcox Co.'s Barberton, Ohio, plant, during which time he was largely responsible for the development of welding techniques and inspection methods which permitted the safe manufacture by welding of boilers, superheaters, pressure vessels and penstocks. Pressures, sizes and wall thicknesses had become too large for conventional riveted or mechanical joints; seamless forgings also were either too expensive or too small.

In 1940 he became vice-president and director of Wellman Engineering Co., manufacturers of ore unloaders, steel mill machinery and heavy handling equipment, and during World War II managed its plant in Akron especially equipped to build heavy items of ordnance and other war equipment. In 1954 he became president of Wellman Engineering Co., succeeding A. E. Gibson on his retirement.

In view of his work on pressure vessels, Hodge is regarded as an American authority on welding and has been an active member of the American Welding Society, receiving its J. F. Lincoln Gold Medal in 1938. In 1954 he presented the Sauveur Memorial Lecture before the Boston Chapter of the A.S.M. on "Some Metallurgical Observations on the Welding Process".

William E. Mahin

WILLIAM E. MAHIN has initiated a new consulting service to various industrial firms on the organization and management of their research and development activities. He has opened offices at Cambridge, Ohio.

Mahin's experience has been closely allied to the new enterprise. Furthermore, the critical shortage of scientific and engineering personnel in America requires that the current supply of metallurgical talent be efficiently used. He graduated in metallurgy from the University of Notre Dame in 1928, where his noted father was head of the department. Entering the employ of Westinghouse Electric he rose to the position of manager of metallurgical engineering for the East Pittsburgh works. Shortly after the war he became director of research at Armour Research Foundation in Chicago, and later technical director of Vanadium Corp. of America's research center in Cambridge, Ohio.

Immediately before entering his new activity he was vice-president and director of research for Hunter Engineering Co. of Riverside, Calif., where he built up a large staff to develop new fabrication methods for light metal alloys.

In post-war years he has devoted a considerable part of his time to important surveys for the U.S. Government. The first of these activities was for the Metallurgical Advisory Board during the Korean War, when he surveyed the work on titanium then under way by various governmental departments and industrial firms, and made broad recommendations for coordinating and continuing the work and particularly for large-scale production of titanium and strong titanium alloys.

Another service was the appraisal (undertaken with C. S. Barrett for the National Academy of Sciences) of the extensive work done by the Ship Steel Committee on brittle welds; recommendations were made for further course of action.

Bill Mahin is an active member of the . Chairman of the Chicago Chapter in 1951, chairman of the National Publications Committee in 1953 and chairman of the Advisory Committee for Metallurgical Education in 1955, he is now heading up a study group reporting to the Board of Trustees on the problems of organizing programs of wide appeal for annual and regional meetings and for efficient publication of the ever-increasing volume of scientific and technical papers.

Among his other professional activities are membership on the Research Fund Committee of the American Society of Tool Engineers and membership on the Scientific Advisory Council of the Rock Island Arsenal.

H. F. Coyle has been transferred by Leeds & Northrup Co., to Philadelphia from the Chicago office to become manager of the transportation and machinery section, market development division. Mr. Coyle was located in Chicago for approximately 25 years.

(Personals Continued on p. 100)

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Personals . . .

Felix E. Wormser, assistant secretary of the U.S. Department of the Interior, has been named 1956 recipient of the Egleston Medal, Columbia University's highest award for "distinguished engineering achievement", sponsored by the Columbia Engineering School Alumni Association. Mr. Wormser was a vice-president of the St. Joseph Lead Co., and president of the Lead Industries Association prior to his appointment to the Department of the Interior in 1953.

Anthony Fortuna has joined Radioplane Co. as assistant quality-control manager and is in charge of quality control at Holloman Air Force Base, N. M.

Thomas J. Moore, Jr. has been appointed director of purchases for the LaSalle Steel Co., Chicago, in addition to which he will also direct material and production planning. Mr. Moore went to LaSalle from Washington, D. C., where he has completed an assignment as director of the Iron and Steel Division, Business and Defense Services Administration, U.S. Department of Commerce. Since 1946 he has been connected with the Sharon Steel Corp. and its subsidiaries in various capacities. For the past four years he served as general manager of the Brainard Steel Div., Warren, Ohio.

James K. Stanley has been appointed supervisor of the silicon steels and magnetic materials research section of Crucible Steel Co. of America at the research and development laboratory in Pittsburgh. Dr. Stanley was previously supervisor of metallurgy in the materials division of Standard Oil Co. of Indiana. Dr. Stanley is author of the book, "Metallurgy and Magnetism", published by A.S.M., as well as numerous other papers. He received his B.Sc. degree in metallurgy from Case Institute of Technology, and a doctorate in metallurgy from the University of Pittsburgh.

Max Hansen was elected president of the Deutsche Gesellschaft für Metallkunde for the three-year period 1956-1958. Dr. Hanson was formerly manager of the metals research department of Armour Research Foundation, Chicago, and since his return to Germany a year ago is vice-president of Metallgesellschaft A.G., Frankfurt-am-Main.

Three New Metal Progress Representatives

Wm. J. Hilty

Donald J. Walter

C. Robert Bilbrey

Three new advertising sales representatives have been recently added to the *Metal Progress* staff.

WILLIAM J. HILTY is the Cleveland-Pittsburgh district manager for *Metal Progress*. A graduate of Fenn College and a bombardier-navigator in World War II, Mr. Hilty was associate account executive with Fuller & Smith & Ross, Inc., Cleveland, for three years immediately prior to joining the *Metal Progress* sales staff. Previously, he was advertising manager of the Flxible Co., Loudonville, Ohio. He works out of national headquarters in Cleveland.

DONALD J. WALTER is the new Detroit district manager covering western Michigan, western Ohio, and New York State. With F. B. Hubert Advertising Counselors, Detroit, as copy and program director for the past three years, his job included market analysis, purchase of media, copy writing, as well as client contact for 20 industrial accounts. Before that, Mr. Walter had served as ad manager of Goddard & Goddard Co., Detroit, and as a sales correspondent at United States Rubber Co., also Detroit. His office is at 20050 Livernois Ave.

C. ROBERT BILBREY, a graduate of Purdue University with a B.S. degree in industrial education, has been appointed district manager in Chicago. Mr. Bilbrey comes from the Dormeyer Corp., Chicago, where he was assistant advertising manager of the power tool division. He previously had been with Schwimmer and Scott, Inc., Chicago advertising agency. With offices at 53 W. Jackson Blvd., Chicago, Mr. Bilbrey will cover the midwestern territory, including Illinois, Wisconsin, Minnesota, western Michigan, Indiana, Iowa, Missouri and Kentucky.

CHIPS DISSTON SAYS

"Be a Sharp Buyer!"

Choose the new DISSTON *Lancer Tooth Band Saw*

FOR HIGH-SPEED CUTTING OF NON-FERROUS METALS

LANCER TOOTH

Use this newly designed Disston hard edge blade with positive rake angle tooth. It permits high-speed production cutting of non-ferrous metal, wood and plastic—cuts brass and aluminum solids and Plexiglas with equal ease.

REGULAR TOOTH

Use this fine Disston hard edge flexible back band saw for all ferrous metals and the thinner sections of non-ferrous metal, wood and plastic. Its finer tooth spacing is particularly adapted to sawing angle iron, steel tubing, nickel plate and brass sheets.

Contact your Disston distributor for these and other high quality Disston cutting tools. Get his expert advice on selecting the right tool for your application.

Henry DISSTON DIVISION HKP

H. K. Porter Company, Inc.

3102 Tacony, Philadelphia 35, Pa.

DISSTON

Personals . . .

Walter J. Piper is now employed in the jet division of Thompson Products, Inc., Cleveland.

Dorothy J. Rahn, formerly metallographer, Firth Sterling, Inc., Pittsburgh, is now metallurgical engineer, Westinghouse Electric Corp., Pittsburgh, heading a new metallurgical laboratory for commercial atomic power activities.

Charles E. Hanson was recently appointed sales manager, Plastic Metals Division, National U. S. Radiator Corp., New York.

James G. Duff, Jr. recently resigned from Thompson Products, Inc., Cleveland, to become lamp wire engineer with the Cleveland wire plant of General Electric Co.

Forest C. Monkman, Jr. was recently appointed director of research for the Walworth Co., Boston.

Bruce F. Richardson has resigned as director of research, Steel Castings Institute of Canada, to head the newly formed Alloys Division of Quebec Metallurgical Industries, Ltd., Ottawa, where he will specialize in the production and sale of parts manufactured from cobalt alloys of his own development.

Lawrence J. Kashar is now employed by the United States Metals Refining Co., Carteret, N. J., as an assistant in the metal powders research section. Mr. Kashar is also taking postgraduate work at Stevens Institute of Technology, studying toward a Master of Science degree in metallurgy.

Charles Braglio has been transferred by the Aluminum Co. of America from the New Kensington, Pa., branch, where he was assistant manager, sales development division, to the Pittsburgh offices, as manager of jobbing sales.

James G. Darrah, who received his Ph.D. degree from Lehigh University last June, is now employed in the engineering division at Chrysler Corp., Detroit.

Frank A. Zorko is now plant metallurgist for the Cleveland welds plant, lamp division, General Electric Co.

P&H Welding Positioner

Doubled Production

— free report shows how

A P&H positioner can cut your welding costs up to 60%, because it reduces waste-motion and fatigue. It is the only positioner available with a safe tilting range of 135 degrees. A pushbutton quickly and easily rotates, tilts, or moves the piece vertically to provide economical downhand welding.

Because welders are always working in a downhand position, they can deposit metal up to twice as fast.

Read about the money-saving, production-boosting features in the complete impartial report offered here. Just mail the coupon.

HARNISCHFEGER
MILWAUKEE 46, WISCONSIN

I'M SMOOTHARC SCOTTY..
with a certified, impartial report that shows how P&H positioners doubled production. It's free...and it may help you save money on your welding operations. Just send for it.

SEND COUPON TODAY FOR **FREE** REPORT!

3106

P&H **HARNISCHFEGER CORPORATION**
4549 W. National Ave., Milwaukee 46, Wis.
Attention: W. R. Stephens, Sales Manager

I am interested in Report No. W-5408.
Please send my copy.

Name _____ Title _____
Company _____
Company Address _____
City _____ Zone _____ State _____

the P&H Line

P&H welding equipment is manufactured and sold in Canada by REGENT EQUIPMENT MANUFACTURING COMPANY LTD., 455 King Street West • Toronto, Ontario, Canada

Personals . . .

H. O. Hanzlik has transferred from the Kansas City, Mo., aviation gas turbine division, metallurgical section, of Westinghouse Electric Corp., to the materials and standards engineering section of the electronics division in Baltimore, Md.

Harold Helgerson, formerly chief metallurgist for Rockwell Valves, Inc., Sulphur Springs, Tex., is now employed as plant metallurgist for Security Engineering Co., Whittier, Calif.

William R. Beavan, Jr., who graduated from Virginia Polytechnic Institute last June with a B. Sc. degree in metallurgical engineering, is now engaged as a supervisor trainee for Republic Steel Corp., Cleveland.

Jack Wagner is now with Allison Div., General Motors Corp., Indianapolis, Ind.

Richard A. Swalin, formerly research associate, General Electric Research Laboratory, Schenectady, N. Y., is now an assistant professor in the department of metallurgy at the University of Minnesota.

George A. Lee, formerly research engineer for North American Aviation Co., Los Angeles, is now titanium project engineer, material and process control department, Northrop Aviation, Inc., Hawthorne, Calif.

Elmer F. Chapin is now serving as raw materials representative in Canada for the U.S. Atomic Energy Commission, with headquarters at Eldorado Mining and Refining, Ltd., Port Hope, Ont.

Clifford L. Dotson, formerly metallurgist at Southern Research Institute, Birmingham, Ala., recently joined the Youngstown Sheet and Tube Co., Youngstown, Ohio, as product development engineer.

John B. Schroeder recently resigned from the atomic energy division of E. I. du Pont de Nemours & Co., Inc., to accept a position with the structural chemistry division of Battelle Memorial Institute, Columbus, Ohio.

T. L. Lee is now manager of Rockdrawn Tube sales at Tube Reducing Corp., Wallington, N.J.

Peerless Aluminum Foundry uses

Machlett

Industrial Electron Tubes

to achieve

Quality Control In Depth —

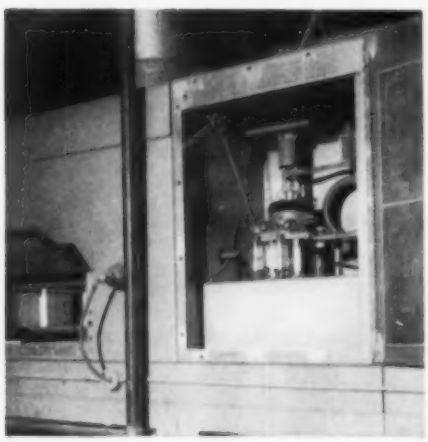
Close tolerance, high quality castings – at good production rates

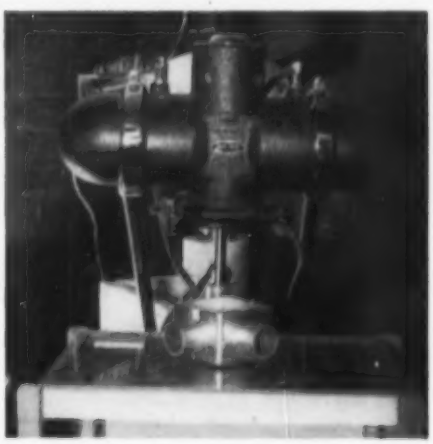
Electronic Foundry Core Baking

ML-5604

X-Ray Inspection

INDUSTRIAL THERMAX





The largest independent aluminum foundry in the East, Peerless Aluminum Foundry, Bridgeport, Conn., produces intricate, close tolerance castings for critical military applications. To meet quality and tolerance specifications Peerless relies on industrial electronics and Machlett electron tubes for...

Electronic core baking . . . reduces time from green core to pouring from six-eight hours to one. Evenly baked, cool cores leave the core baker and their moisture-free characteristics assure gas-free castings.

X-Ray Inspection ... for fluoroscopic examination of routine production, and for quick examination of first pours . . . by radiography, where permanent records are required.

ML-5604
Machlett Original Design

. . . The most used industrial oscillator tube for medium-high power dielectric heating installations. Rugged construction assures long, maintenance-free operation at high output powers.

INDUSTRIAL THERMAX
Machlett Original Design

. . . Heavy duty, compact, yet light weight x-ray tube unit adaptable to many uses. Provides stable operation for tens of thousands of radiographic exposures or thousands of fluoroscopic inspections.

MACHLETT

FIRST IN INDUSTRIAL ELECTRON TUBES

MACHLETT LABORATORIES, INC., Springdale, Connecticut

Personals . . .

William A. Dennis has been appointed assistant metallurgical engineer in the steel operating division of United States Steel Corp., Pittsburgh. Mr. Dennis was formerly resident service metallurgist in New England for the same corporation.

D. M. Lormier is now development support engineer with the pilotless aircraft division, Boeing Airplane Co., Seattle, Wash.

F. P. Whalen has been transferred from division metallurgist, Cleveland, to works metallurgist in the Worcester, Mass., plant of American Steel & Wire Div. of U.S. Steel Corp.

George H. Keith has returned to graduate school at Stevens Institute of Technology upon release from active duty with the U.S. Army, and is working towards his master's degree in metallurgy. Mr. Keith is also working as a graduate assistant in the school.

Jerome A. Rounds is now resident sales representative for the San Antonio and Austin, Tex., territory for Earle M. Jorgensen Co., Houston, Tex.

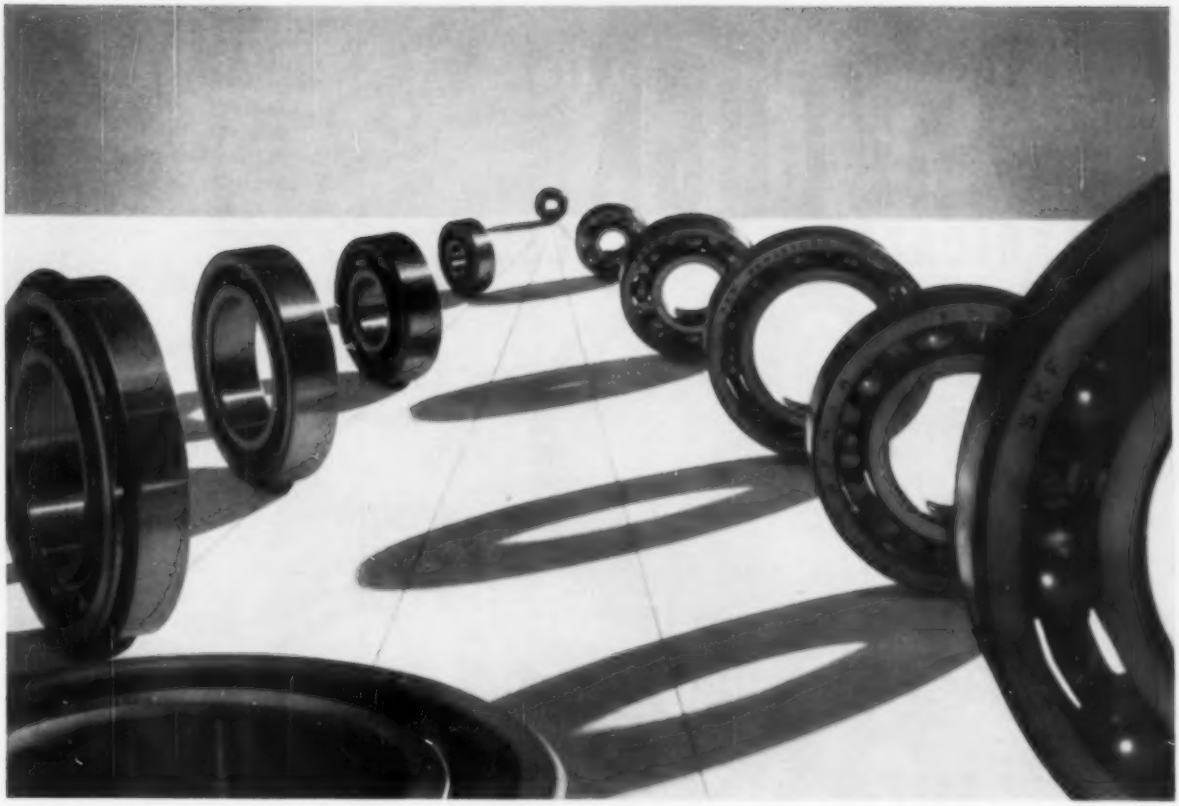
Normand Hyman, having completed his tour of duty as a lieutenant in the U.S. Air Force, working as a project engineer at Wright Air Development Center, is now a metallurgist for Crucible Steel Co. of America, Syracuse, N. Y.

Bernard P. Planner is now senior development engineer, Marquardt Aircraft Co., Van Nuys, Calif.

David T. Blair, formerly laboratory project engineer, Vickers, Inc., Detroit, is now engineering manager for Blackhawk Mfg. Co., Milwaukee, Wis.

Richard C. Barry, until recently materials engineer at the Naval Radiological Defense Laboratory, San Francisco, has joined Westinghouse Electric Corp. at the Bettis plant in Pittsburgh.

Joseph C. Danko received his Ph.D. degree in metallurgical engineering from Lehigh University in October, where he remains for the 1955-56 term as part-time instructor and research associate.



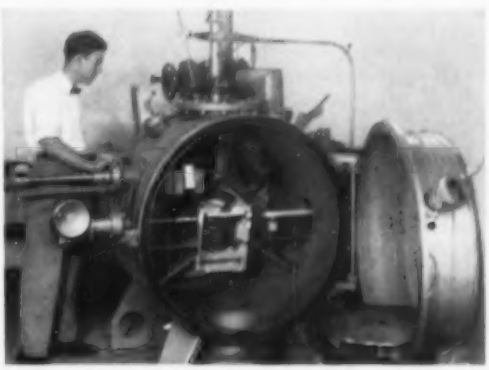
Will Vacuum Melted Metals do for YOUR Product what they do for Ball Bearings?

A Vacuum Furnace will help you get the Answer

Vacuum melted steels are consistently free of inclusions and exceptionally clean. As a result they provide for ball bearings:

1. Bearing life consistently 100% to 200% better than handbook ratings for normal temperature operations.
2. Bearing life consistently up to 600% longer for high temperature, high speed applications.
3. Up to 90% reduction in bearing race rejects.

Would metals with such characteristics make *your* product better? A vacuum furnace will enable you to develop materials especially suited to your needs. We have made and operated more high vacuum furnaces than any other manufacturer in the world. Can we help you, too? Send coupon below today.



NRC Model 2555 Vacuum Furnaces are now being used by aircraft companies, engine manufacturers, investment casters, specialty steel producers to speed up development of new materials that will meet ever more severe operating requirements.

Other NRC high vacuum products include: analyzers, dehydrators, freeze driers, impregnators, gauges, metallizers, pumps, valves.

NRC

NRC EQUIPMENT DIVISION

NRC EQUIPMENT DIVISION
NATIONAL RESEARCH CORPORATION
Dept. 13, Charlemont Street, Newton Highlands 61, Massachusetts

Please send me Model 2555 Data Sheet ☐ NRC Vacuum Furnace Bulletin ☐
Have your representative call ☐

Name.....Title.....
Company.....
Address.....
City.....Zone....State.....

Personals . . .

Hans Conrad recently joined the metallurgy department of the Westinghouse Electric Corp., research laboratories as a research metallurgist to do basic research on the deformation of metals. Mr. Conrad was previously associated with the Chase Brass & Copper Co., research laboratories in Waterbury, Conn.

William S. Montgomery has been transferred by Hevi Duty Electric Co. from the New Jersey office, where he was a sales engineer, to the Los Angeles office as district manager of West Coast sales.

Bruce C. Clark recently left the Midvale, Pa., smelter of U.S. Smelting, Refining & Mining Co., to assume the position of assistant metallurgist at the Dumas, Tex., smelter of American Zinc Co. of Ill.

R. D. Randall, formerly chief engineer with Annin Co., Los Angeles, is now manager of research engineering with the South Wind Div. of Stewart-Warner Corp. in Indianapolis, Ind.

Gil Jarman has been promoted from general sales manager to vice-president in charge of sales for Marshall Steel Co., McCook, Ill.

Harry P. Dobrow is now a fellow engineer with the atomic power division of Westinghouse Electric Corp., Bettis Field, Pittsburgh, in the advance planning and development department. Mr. Dobrow was formerly assistant to the vice-president of Alloy Engineering & Casting Co., Champaign, Ill.

Evangelos Melpides has been appointed assistant professor at National Technical University of Athens, Greece, in the department of metallurgy. He is working also as assistant director at the Eleusis Steel Co., Athens. Mr. Melpides received his B.S. degree in chemical engineering in 1944 in Greece, and continued graduate courses in metallurgy at the University of Maryland and Colorado School of Mines.

Paul E. Fortin, after postgraduate work at Laval University, has joined the Aluminum Co. of Canada, Ltd., with a permanent assignment for work at Arvida, P. Q.

SPECIAL PROPERTIES OF TIN INCREASING VALUE OF STRAITS TIN FROM MALAYA TO AMERICAN INDUSTRY

New Applications Cutting Costs in Wide Range of Industrial Fields

New uses for tin today are being discovered as rapidly as new products and new processes are developed. For no other metal combines all the special properties that make tin so valuable to industry.

Tin is corrosion resistant, nontoxic, inert and tasteless — the best metal for packaging foods. And many more food products are now being packed in tin cans.

Tin wets metals readily, flows easily, adheres firmly, and has a relatively low melting point. Tin is the key constituent of solder, and today improved equipment and processes are making solder still easier and more economical to use.

Tin hardens and strengthens copper twice as effectively as zinc, and provides better resistance to corrosion.

Because tin has excellent antifriction, conformability and embedding characteristics, it is invaluable as a bearing metal. Now, new tin bearing alloys (such as 20% tin-aluminum) are producing excellent results in actual performance tests.

And what is most important, Straits Tin is economical to use in any application, because it takes so little tin to do so much work!

Tin has, in fact, always been a remarkable metal. And after fifty centuries there is still no apparent limit to its usefulness. Whether you are planning a new product or process, or seeking to improve a present one—plentiful, dependable, economical Straits Tin from Malaya may profitably answer your problem.

STRAITS TIN NEWS & NOTES

More than 40% of the free world's tin metal is produced in Malaya. Called Straits Tin, this metal is at least 99.87% pure and known everywhere for its absolute reliability of grade.

★

Tin's versatility has always been a key factor in American industrial progress. In the wonder world of modern electronics, high-tin solders are now being used in thousands of critical places where corrosion-resistant, impermeable, electrically conductive joints are essential.

★

The most significant result of the 1955 elections in Malaya is greater political and economic stability. The tin industry is represented in the Federation's new Government, and one of the Government's major aims is to facilitate tin prospecting.

★

Straits Tin is not only one of the world's most important metals. It is now one of our most useful chemicals, especially in the ceramic and plastics industries.

★

Today there is plenty of Straits Tin. The extent of known reserves, geologists say, is adequate for the foreseeable future whatever the requirements of American industry may be. And with America's awareness of the strategic importance of Malaya, key to Southeast Asia, the supply of tin will continue to be fully as dependable as the supplies of other materials produced in the free world.

Personals . . .

Richard William Meek has accepted a position as metallurgist with the security engineering division of Dresser Operations, Inc., Dallas, Tex.

Phillip K. Schneider is now employed as a metallurgical trainee in the Sanderson-Halcomb Works of Crucible Steel Co. of America, Syracuse, N. Y.

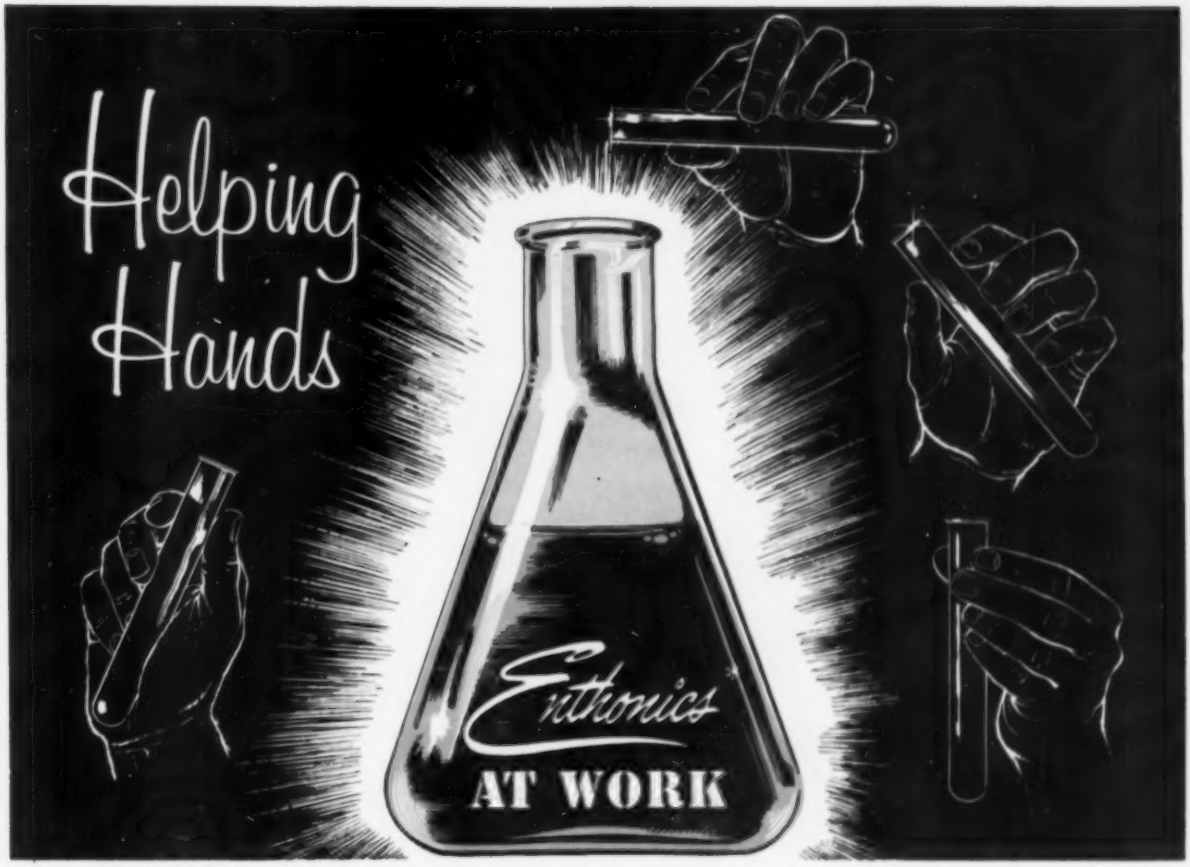
Julius S. Furman, formerly specifications examiner for United States Steel Corp., Pittsburg, Calif., is now a metallurgist in the testing laboratory of Consolidated Vultee Aircraft Corp., Fort Worth, Tex.

Earl Beyerlein has been transferred by Eaton Mfg. Co. from the axle division in Cleveland, to the foundry division in Vassar, Mich.

Jack Keverian has been appointed manager of applied research and development and will head the new laboratory established by General Electric Co., at Schenectady, N. Y., to deal specifically with foundry problems and processes. Dr. Keverian, a native of Everett, Mass., received his B.S., M.S. and D. Sc. in metallurgy, from the Massachusetts Institute of Technology.

Herbert R. Toler has been added to the staff of the research department of the Indiana Steel Products Co., Valparaiso, Ind., as research engineer. Mr. Toler was formerly a ceramics engineer with American Terra Cotta Corp., Crystal Lake, Ill. He is a graduate of the University of Illinois, with both B.S. and M.S. degrees in ceramic engineering.

Emil G. Holmberg has joined the corrosion engineering section of the International Nickel Co.'s development and research division in New York. Mr. Holmberg for the past nine years was chief metallurgist of the Alloy Steel Products Co., Linden, N. J. Prior to this he had served as a metallurgist with E. I. du Pont de Nemours & Co., Inc., and as an instructor in engineering subjects at the Newark School of Fine Industrial Arts, Newark, N. H. He holds the degree of engineer of mines from the Colorado School of Mines.



FROM THOUSANDS of TESTS . . .

. . . *come the solutions to your metal finishing problems.*

If *you* are looking for creative chemistry to supply new methods for the improvement of metal finishing, look to the leader – ENTHONE. Write for the answers to these problems, identifying them by number. If your specific problem is not listed, Enthone will gladly help to find the answer.

1. HOW TO BLACKEN copper, brass, zinc, steel and other metals to meet U.S. Government specifications.
2. HOW TO STRIP NICKEL from steel without etching the steel.
3. HOW TO STRIP NICKEL from copper and brass without attacking the part.
4. HOW TO SHED WATER from metals to prevent staining or spotting during drying.
5. HOW TO TRAP FUMES from hot sulfuric acid pickles.
6. HOW TO STRIP SYNTHETIC ENAMELS from aluminum and other metals without attacking the metal.
7. HOW TO CLEAN AND REMOVE RUST AND OXIDES from steel in one operation without acids.
8. HOW TO RINSE AND DRY STEEL WITHOUT RUSTING, using cold or hot water.
9. HOW TO SHORTEN ALKALI CLEANING TIME for steel to 15 seconds.
10. HOW TO REMOVE SOLID DIRT AND OIL from metals.
11. HOW TO STRIP LEAD, TIN or soft solder from copper and brass with no etching.
12. HOW TO PLATE METALS upon aluminum.
13. HOW TO REMOVE EXCESS SILVER SOLDER chemically from silver brazed steel parts.
14. HOW TO MAKE PAINT STICK to brass and zinc.
15. HOW TO SOLVENT-CLEAN parts and assemblies with cold non-hazardous solvent.
16. HOW TO OVERCOME CHROMIC ACID CONTAMINATION in cleaners.
17. HOW TO PREVENT STAINING of chromium plate.
18. HOW TO GIVE ZINC AND CADMIUM high salt spray resistance.
19. HOW TO COLOR ALUMINUM in one operation.
20. HOW TO STRIP METAL COATINGS from zinc die castings.

* *The Scientific Solution of Metal Finishing Problems.*

ENTHONE

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ELECTROPLATING CHEMICALS • METAL FINISHING PROCESSES

Service Representatives and Stock Points in Principal Cities of U.S.A. and Canada, Mexico, Brazil, England, France, Sweden and Germany.

Personals . . .

Emmett Mann, who started as a sales engineer with Alloy Metal Wire Co., division of H. K. Porter Co., Inc., Prospect Park, Pa., has been appointed general manager of the division, as well as elected a vice-president of the parent organization. Immediately prior to this appointment, Mr. Mann was sales manager of Alloy Metal Wire. He is a graduate of Rensselaer Polytechnic Institute.

F. H. Mulligan has been elected president of Charles Hardy, Inc., New York. Joining the company in 1919, four years after its founding, Mr. Mulligan has held a variety of managerial positions prior to his election as president. For the past ten years, he has been vice-president and a director, and before that served as secretary. A former director of the Metal Powder Association, Mr. Mulligan was honored in 1951 as one of 35 pioneers of the metal powder industry.

Chester E. Davis, executive vice-president of Alan Wood Steel Co., Conshohocken, Pa., has been elected a member of the company's board of directors. Mr. Davis has been associated with Alan Wood Steel for the past 25 years. He joined the company as industrial engineer in 1930.

E. Kendrick Leavenworth has been transferred by Climax Molybdenum Co., from the research laboratory in Detroit, where he has held various supervisory positions since 1943, to the technical processes and economic engineering staff in New York. Mr. Leavenworth is a 1928 graduate of the Yale Sheffield Scientific School.

Herman J. Brenneke was recently promoted by the Socony Mobil Oil Co., Inc., from lubrication engineer for the Wadhams Div., and transferred to the New York office. In his new position, Mr. Brenneke will spend a part of his time as assistant to the chief engineer of indirect marketing for Socony Mobil Oil Co., Inc., and the remainder of his time with the newly formed Mobil Overseas Co., with duties which will involve travel to all parts of the world.

For Faster Ingot Heating, Specify Salem-Brosius Rectangular Pits

This installation of Salem-Brosius rectangular, gas-fired soaking pit furnaces conditions steel ingots for further processing—works around the clock for one of the country's outstanding steel makers. Ingots are heated faster, more uniformly and at lower cost in these furnaces. Double-pass, metallic, needle-type recuperators that preheat combustion air and reduce fuel costs are an outstanding feature of the design. Low maintenance, easy operation and long service life are standard with Salem-Brosius designed furnaces.

Salem-Brosius engineers are specialists in performance and control of heat in manufacturing, offering furnaces custom-built to your requirements. Salem-Brosius furnaces assure you maximum high-quality output at minimum initial, operating, and service costs.

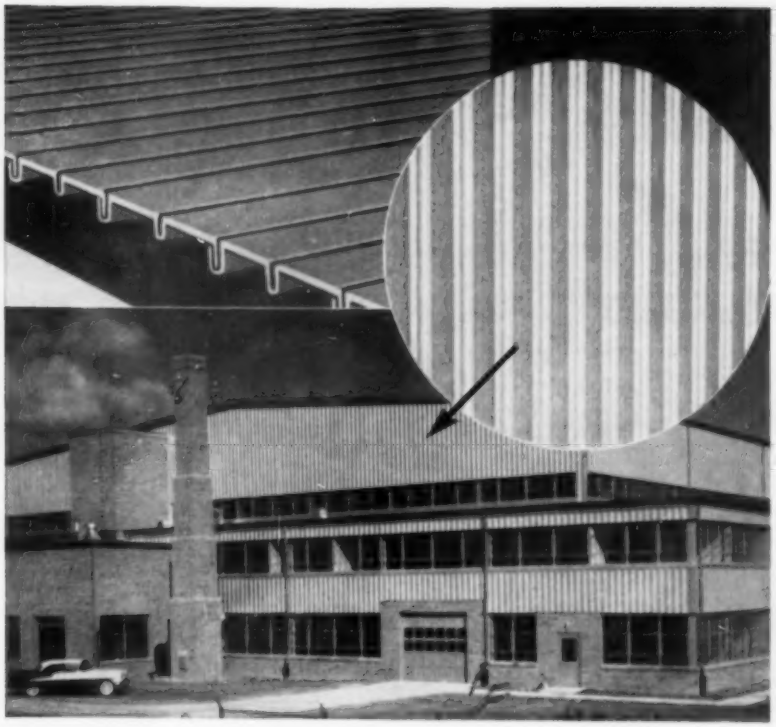
We would like to tell you more about the efficiency of these new units, and also about the well-known Salem-Brosius circular soaking pits.

If your modernization or expansion plans call for heating or heat treating furnaces of any kind, write, wire, or phone Salem-Brosius.

SALEM-BROSIUS, INC.

CARNEGIE, PENNSYLVANIA

IN CANADA: SALEM ENGINEERING LTD. · 1525 BLOOR STREET WEST, TORONTO 9, ONTARIO



(TOP) *Cross-section of cold-roll-formed Roof Deck by Walker Supply & Mfg. Co., Ecorse, Michigan.*

(INSET CIRCLE) *Aluminum siding panels, (made by Walker Supply & Mfg. Co.) give fine architectural effect.*

Elevator Door, Casing and Trim, by Dahlstrom Metallic Door Co., Jamestown, N. Y.

1001 things being done by COLD ROLL FORMING

The Cold-Roll Forming Machine is a powerful weapon in the hands of mass-production metal-working industries striving to fight inflationary forces with technological advances.

This applies even to the building industry, long considered immune to mass-production methods. The field abounds in opportunities for cost reduction through cold-roll forming of components for quick and easy assembly and erection on the job. The list includes, for example, specially designed wall, partition, floor and roof systems, nailable studs and joists, cabinets, closets, windows, doors and trim. It even includes exterior coverings, for architectural beauty as well as insulation and weather protection (see photo above).

The Yoder Book on Cold-Roll Forming contains numerous illustrations with information on the economic and mechanical possibilities of cold-roll forming, the machines and the tooling. Yoder has long been looked up to as the leader in designing and building all such equipment. A copy of the book is yours for the asking.

THE YODER COMPANY • 5595 Walworth Avenue, Cleveland 2, Ohio

ENGINEERING YODER MANUFACTURING

COLD ROLL FORMING MACHINES
ROTARY SLITTING LINES
PIPE AND TUBE MILLS—Electric Weld

Personals . . .

Fred W. DeMoney has been appointed head of the mechanical metallurgy and evaluation section of Kaiser Aluminum & Chemical Corp.'s department of metallurgical research at Spokane, Wash. **Roger D. Olleman** has been appointed assistant section head. Prior to joining Kaiser Aluminum, Dr. DeMoney served as research metallurgist with Dow Chemical Co., and as a staff engineer with Kimberly Clark Corp. Dr. Olleman formerly was a research metallurgist with Westinghouse Electric Corp. In 1954, his work in connection with testing techniques at low temperatures earned him the Templin Award of the American Society for Testing Materials.

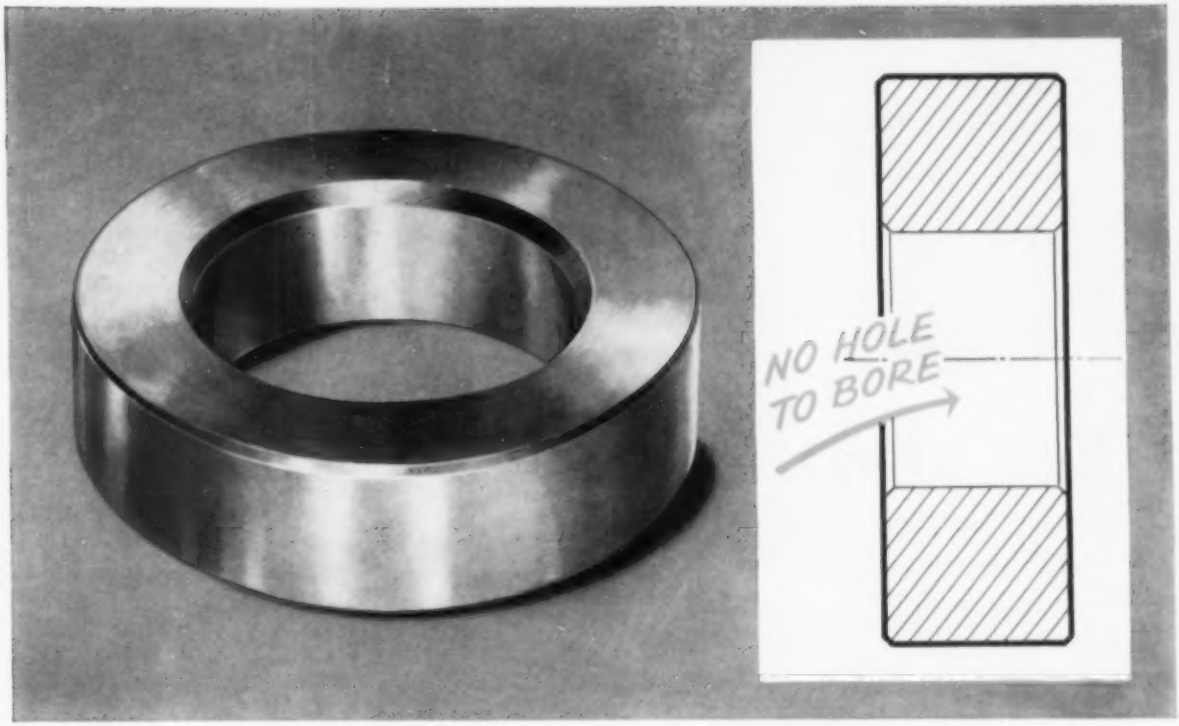
Irwin L. Tunis is employed as a research engineer at the research laboratory of Jones & Laughlin Steel Corp., Pittsburgh.

Paul J. Kondla has been appointed supervisor of the metal chemicals section of American Cyanamid Co., New York. Mr. Kondla graduated from the University of Connecticut in 1938 with a B.S. degree in chemistry, and joined Cyanamid in 1952 as eastern sales representative for the metal chemicals section.

Jules F. Saut, a representative of Reynolds Metals Co. in the Detroit area since 1947, has been made the firm's manager of sales to the automotive industry. Mr. Saut is a graduate of the University of Kansas with a B. S. degree in mechanical engineering, and prior to joining Reynolds as technical service engineer was employed by Dow Chemical Co. He has been Reynolds' assistant manager of automotive market sales since 1953.

Karl M. Weigert is to be in charge of brazing research on new methods and materials at the research laboratories at Quehanna, Pa., which are under construction for the Curtiss-Wright Corp. Dr. Weigert was formerly associated with Goldsmith Bros. Smelting and Refining Co., Chicago.

Robert W. Derrick is now employed as specifications examiner at the Columbia-Geneva Div., United States Steel Corp., in the Pittsburg, Calif. Works.



Steps up gear blank production 300% by switching from bar stock to TIMKEN® steel tubing

AN engine manufacturer felt that his gear blanks were costing him too much to make. The center hole had to be bored out of solid bar stock. It took a whole hour to turn out 29 blanks. And a lot of steel was wasted in the process.

So the manufacturer discussed his problem with metallurgists of the Timken Company, experts in fine alloy steel. After study they recommended a change in production methods together with a switch to Timken® seamless steel tubing in place of bar stock.

With Timken seamless steel tubing, the center hole is already there. It doesn't have to be bored out. Finish boring was the engine maker's first production step. And with Timken steel tubing his gear blanks are now being turned out at 120 to 130 an hour—an increase of 300%.

Machining costs have been cut by more than half. And because the center hole is "built-in", no steel is wasted.

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Personals . . .

Marshall K. Garneau is now sales manager of J. Olson Machine Co., Minneapolis, Minn.

John E. Dalton, formerly lubrication engineer with Saginaw Steering Gear Co., Saginaw, Mich., is now a sales engineer for D. A. Stuart Oil Co. in the same area.

M. L. Gruver, formerly superintendent of maintenance for the Midvale Co., Philadelphia, is now staff engineer for Kaiser Steel Corp., Fontana, Calif.

F. S. Gardner has been appointed supervisor of metallurgical research for the transformer division laboratory of the General Electric Co., Pittsfield, Mass.

H. E. Miller was recently transferred from Kaiser Aluminum & Chemical Corp.'s department of metallurgical research in Spokane, Wash., to the Newark, Ohio, rod, bar and wire plant where he is remelt metallurgist.

Robert M. Goldhoff, who graduated from Ohio State University in December 1955 with a Ph. D. degree, is now employed as applied research metallurgist, materials and processes laboratory, large steam-turbine-generator department, General Electric Co., Schenectady, N.Y.

Richard F. Lupi, formerly senior metallurgist for Utica Drop Forge and Tool Corp., is now employed as a metallurgist at the Knolls Atomic Power Laboratory of General Electric Co., Schenectady, N.Y.

Michael V. Nevitt, formerly head of the department of metallurgical engineering at Virginia Polytechnic Institute, is now associate physical metallurgist at the Argonne National Laboratory, Lemont, Ill.

S. W. Winquist has been transferred from the Los Angeles plant of Airesearch Mfg. Co. to the Phoenix, Ariz., plant where he is employed as production design engineer on gas turbines.

Robert J. P. Jensen, who has been serving as manager of the Baltimore branch office, was transferred by Kaiser Aluminum & Chemical Corp. to Boston as manager of the branch office.

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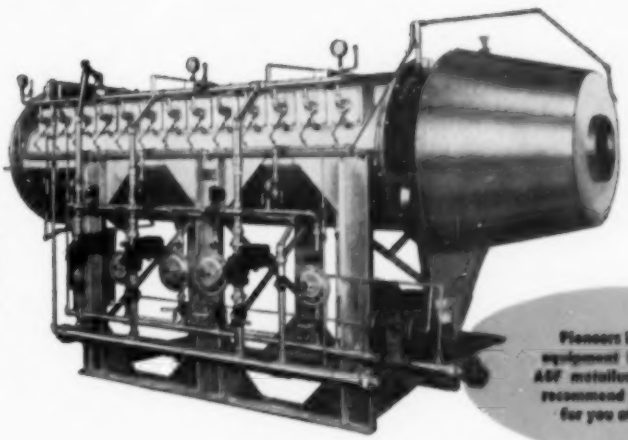

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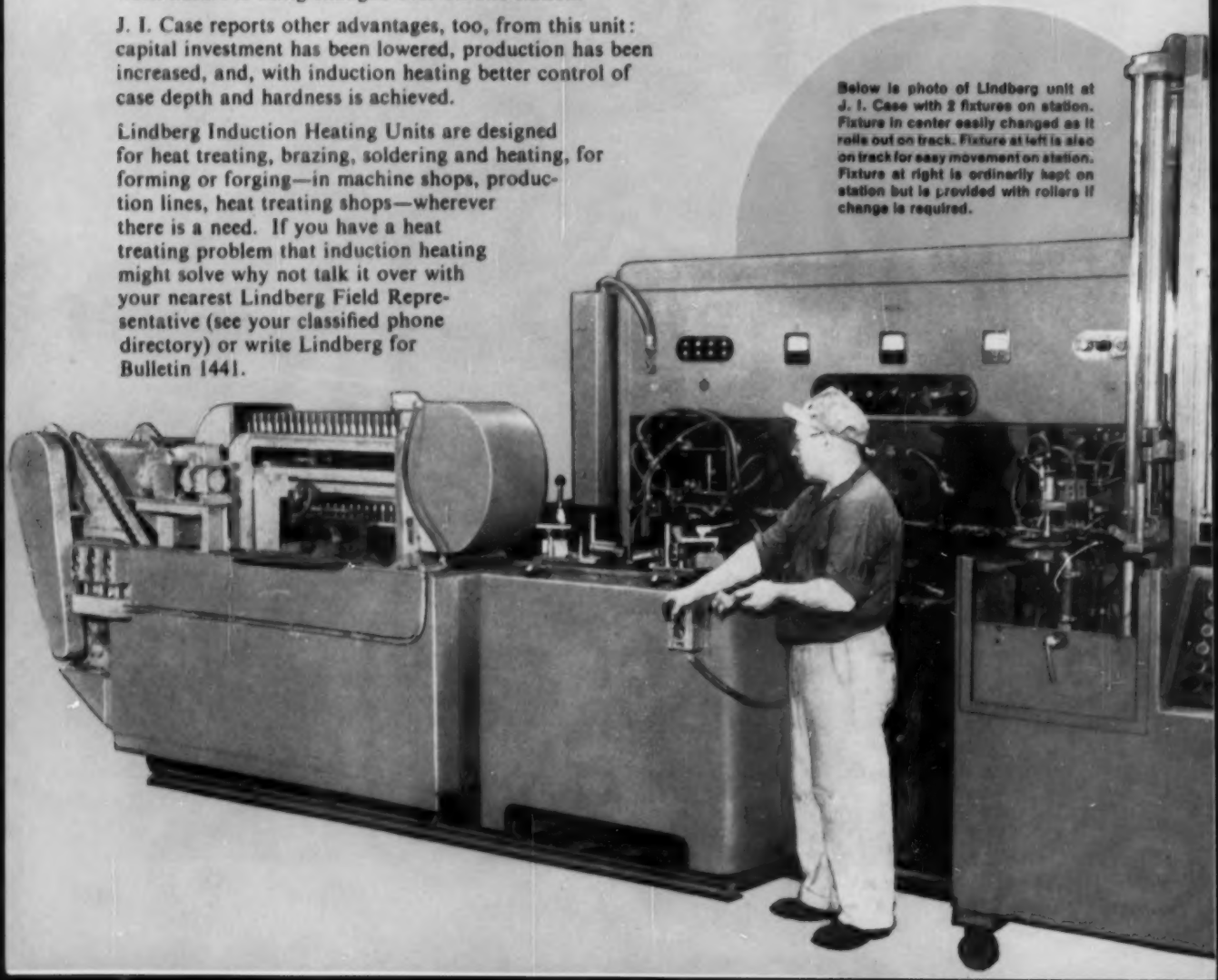
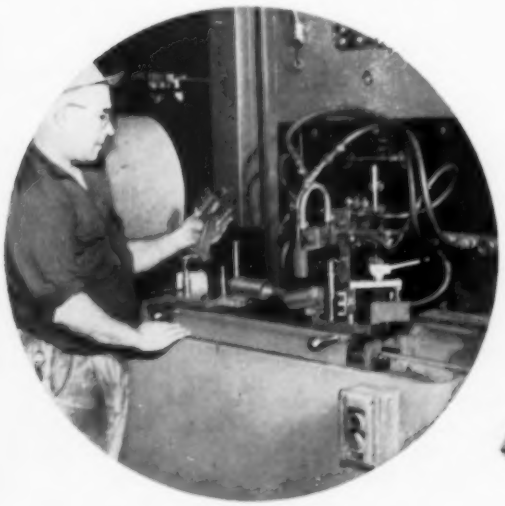


Below is photo of Lindberg unit at J. I. Case with 2 fixtures on station. Fixture in center easily changed as it rolls out on track. Fixture at left is also on track for easy movement on station. Fixture at right is ordinarily kept on station but is provided with rollers if change is required.

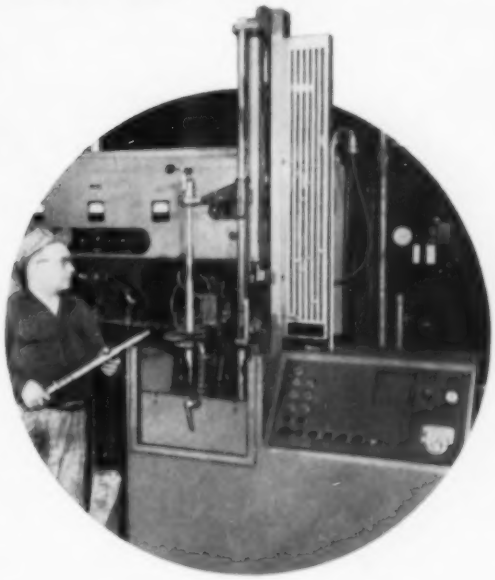
(Above) Hydraulic male coupling is being treated on this fixture. 3 other parts are treated by it, too.

(Above) This shows fixture handling inlet and exhaust valve rocker arms. Same fixture treats 6 other parts.

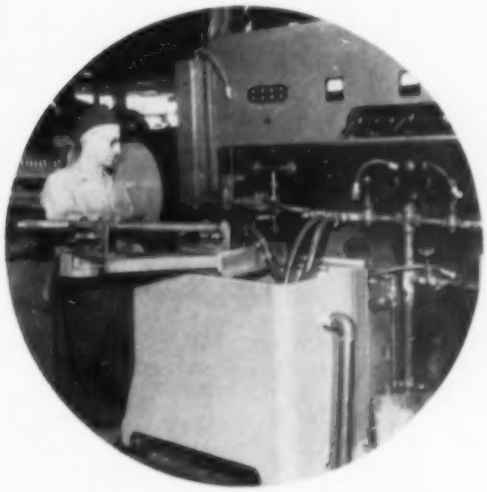


(Above) This fixture is selectively hardening pads and slots on shifter forks. It is also used for treating 17 other parts.

(Below) This fixture is shown selectively hardening a front axle king pin. It handles piece up to 45½" long, 35" of which can be scanned to desired depth. It is also used for 34 other parts.



(Below) Power take-off hydraulic drive shafts are one of the 3 parts treated by this fixture.



Digests of Important Articles

Solubility of Nitrogen in Alpha Iron

Digest of "The Solubility of Nitrogen in Alpha-Iron Containing up to 0.051% Vanadium" (Part 2 of "The Effect of Alloying Elements on the Solubility of Nitrogen in Iron"), by E. T. Turkdogan, S. Ignatowicz and J. Pearson, *Journal* of the Iron and Steel Institute, Vol. 181, November 1955, p. 227-231.

SMALL additions of vanadium reduce strain aging of rimmed steel to virtually negligible amounts. Thermodynamic data are inadequate to prove that this effect is actually due to the stabilization of nitrogen by vanadium. An investigation was recently conducted by the British Iron and Steel Research Assoc. to determine "whether small percentages of vanadium in steel could be responsible for the formation of nitrides at low nitrogen potentials and consequently lower the solubility of nitrogen in iron".

Ribbon-type samples 0.002 in. thick were prepared from two iron-vanadium alloys containing 0.016 and 0.051% V respectively and less than 0.01% of any other element. All samples were annealed in a hydrogen atmosphere to reduce the nitrogen content to 0.0005% or less. Then samples were held for 24 hr. at 930 and 1110° F. respectively in various ammonia-hydrogen mixtures and subsequently analyzed chemically for nitrogen by the micro-Kjeldahl method.

The results show a slow linear increase in nitrogen content with rising partial pressure of ammonia in the gas, up to the value required for iron nitride formation. At this point the nitrogen content increases very rapidly. The curves on both vanadium alloys were practically identical to similar curves on iron at the same temperatures. Evidently the vanadium did not affect the activity coefficient of nitrogen dissolved in iron since there was no formation of vanadium nitride. Microscopic examination showed no second phase in any of the specimens other than iron nitride in the high-nitrogen specimens. The authors conclude that "Vanadium up to 0.05% in solution with alpha iron is not sufficient to form a vanadium nitride phase below the nitrogen potential of Fe_4N."

The discrepancy with previous beliefs may be due to inaccurate thermodynamic data on vanadium nitride. These data are discussed and considered inadequate for calculating the conditions of nitride formation in iron containing vanadium. Certainly from the present work no vanadium nitride is formed at 930° F. in iron containing up to 0.05% vanadium.

In discussing the apparent disagreement between this conclusion and the observed effect of vanadium on strain aging of rimmed steel, other anomalies found in studies of strain aging are pointed out. These include the facts that certain "non-aging" steels have yield points and aluminum steels without silicon are susceptible to strain aging even though they contain enough aluminum to reduce the nitrogen in solution to a negligible percentage.

Although vanadium nitride has been shown not to form at 930° F. in iron containing 0.05% V, it may form on very slow cooling at lower temperatures and affect the aging tendency by a reduction in soluble nitrogen. Possibly carbon, oxygen or sulphur is involved in strain aging and vanadium may form complex compounds with them.

Additional studies are needed of both strain aging in steel and the effect of various alloying elements on this phenomenon.

G. F. COMSTOCK

Fisheyes in Weld-Metal Test Bars

Digest of "Some Investigations of the Causes of Halo Formation", by R. Winterton, *British Welding Journal*, Vol. 2, September 1955, p. 385-392.

THE OCCURRENCE, possible causes and elimination of the bright spots in the fracture surfaces of weld-metal test bars, called fisheyes, are carefully treated in this paper. Attempts were made to relate these spots to the content of hydrogen or oxide inclusions without success.

A statement prepared by the panel of investigators of the British Welding Research Association summarizes the present state of knowledge: "Despite the considerable amount of work which has been undertaken by investigators in this and other countries, the exact mechanism of fisheye (halo) formation is still not clearly understood. It is known, however, that weld metal from titania-covered electrodes seems to be more prone to fisheye formation than other types, and that the principal inclusions in weld metal susceptible to this phenomenon are rhodonite (manganese metasilicate) and manganese sulphide, although there is not sufficient evidence to relate these inclusions with the inception of fisheye (halo) formation is still not to be able to state that the presence of appreciable strain and of hydrogen are necessary factors, and that no fisheyes appear in impact tests on susceptible weld metal.

"The fact that appreciable strain is necessary is exceedingly important and should inspire greater confidence in weld metal generally, as it means that the incidence of fisheyes can only occur at strains which could not be tolerated in the design structure."

Aging, which improves the ductility of welds, only eliminates fisheyes

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Fisheyes . . .

if it is done in vacuum for at least 16 hr. at 1200° F. or higher. Specimens of weld metal nine years old showed fisheyes but had greater ductility and less hydrogen than new welds made with the same materials. Bars strained varying amounts up to 25% elongation and then heated in vacuum at 1200° F. for 16 hr. before testing to fracture indicate the combined effect of strain and hydrogen content on fisheye formation. When the hydrogen in the weld metal is less than 2 ml. per 100 g. there are no fisheyes; with 10 ml. of hydrogen per 100 g., 20 to 23% elongation before heating in vacuum is required to produce them. With 16 ml. of hydrogen per 100 g., only 14% strain produces fisheyes. Test bars broken by an explosive charge show no fisheyes. Notched tensile and impact bars show no fisheyes when made with susceptible metal.

A considerable amount of chemical and X-ray analysis is presented in four tables that also give mechanical properties and occurrence of fisheyes. The actual relation between hydrogen and fisheye formation is obscure. There is some discussion about "diffusible hydrogen" – the portion that would diffuse from the weld metal at "normal temperatures" – and "nondiffusible hydrogen", which is determined by vacuum fusion. Dividing the hydrogen content in this way made much to talk about but did not seem to clarify the situation.

Comparison of five electrodes with varying susceptibility to fisheyes shows that oxide-type covered electrodes produce iron oxide inclusions but no fisheyes, and oxide-cellulose covered electrodes produce fisheyes which can be eliminated by prolonged aging.

Hydrogen potential from water in electrode coverings varied from 3000 ml. per 100 g. in conventional electrodes to 440 ml. per 100 g. in dried low-hydrogen electrodes. Actual hydrogen content in the weld was 18 ml. per 100 g. for conventional electrodes, and 9 ml. for the low-hydrogen. Arc length was one of the variables. Attempts to produce fisheyes by charging steel and hydrogen-free welds with hydrogen electrolytically were unsuccessful.

(Continued on p. 126)

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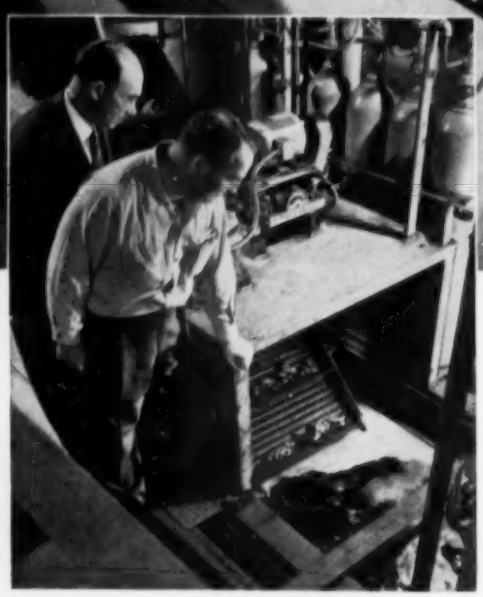

The Gulf Super-Quench in the bath above has been in use for 2½ years at Cummins' Columbus, Indiana plant with only normal makeup oil being added. Cummins is the world's leading independent manufacturer of lightweight, high-speed Diesel engines. Left—Gulf Sales Engineer G. C. Shimer and G. R. Dellinger, Supervisor, Heat Treating Dept., check the rocker lever parts for Cummins Diesels as they emerge from the Super-Quench.

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Fisheyes . . .

It appears that fisheyes are formed by strain on weld metal containing hydrogen. A certain minimum amount of strain is necessary before the fisheye is formed. Time is also an important variable since fisheyes are not formed in impact specimens. The time required for fisheye formation suggests a mechanism involving the diffusion of hydrogen. This is supported by the fact that they are not formed in tensile bars tested at temperatures below −75° F.

DAN WHITE

Metastability of 18-8 Stainless Steel

Digest of "Metastability of Austenite in an 18-8 Cr-Ni Steel", by P. Cina, *Journal* of the Iron and Steel Institute, Vol. 179, March 1955, p. 230 to 239.

AUSTENITE in 18-8 Cr-Ni stainless steel is not stable at room temperature and will transform to ferrite if cold worked or tempered at about 900 to 1300° F. The extent of transformation as a function of cold work and various tempering treatments is reported for an alloy whose composition is 0.12 C, 0.34 Mn, 0.55 Si, 17.86 Cr, 7.90 Ni, 0.34 Mo and 0.29 N.

Annealed samples were cold worked at room temperatures, −60 and −300° F., and then tempered for various times at 930, 1110, 1290 and 1470° F. The amount of ferrite present after each treatment was measured by microscopic examination, X-ray diffraction and magnetic techniques. Accuracy was estimated to be within 5% when about 50% ferrite was present and within 2% for values of 10% or less.

The amount of ferrite increased from less than 5% to almost 10% as the amount of cold work at room temperature was increased from 5 to 15%. Samples worked 15% at −60° F. contained 50% ferrite; at −300° F., the amount of ferrite produced was about 60%.

Tempering of cold worked samples between 930 and 1290° F. increased the amount of ferrite from about 8 to 40% after 672 hr. at temperature. At 1470° F., the amount of ferrite increased only slightly because of

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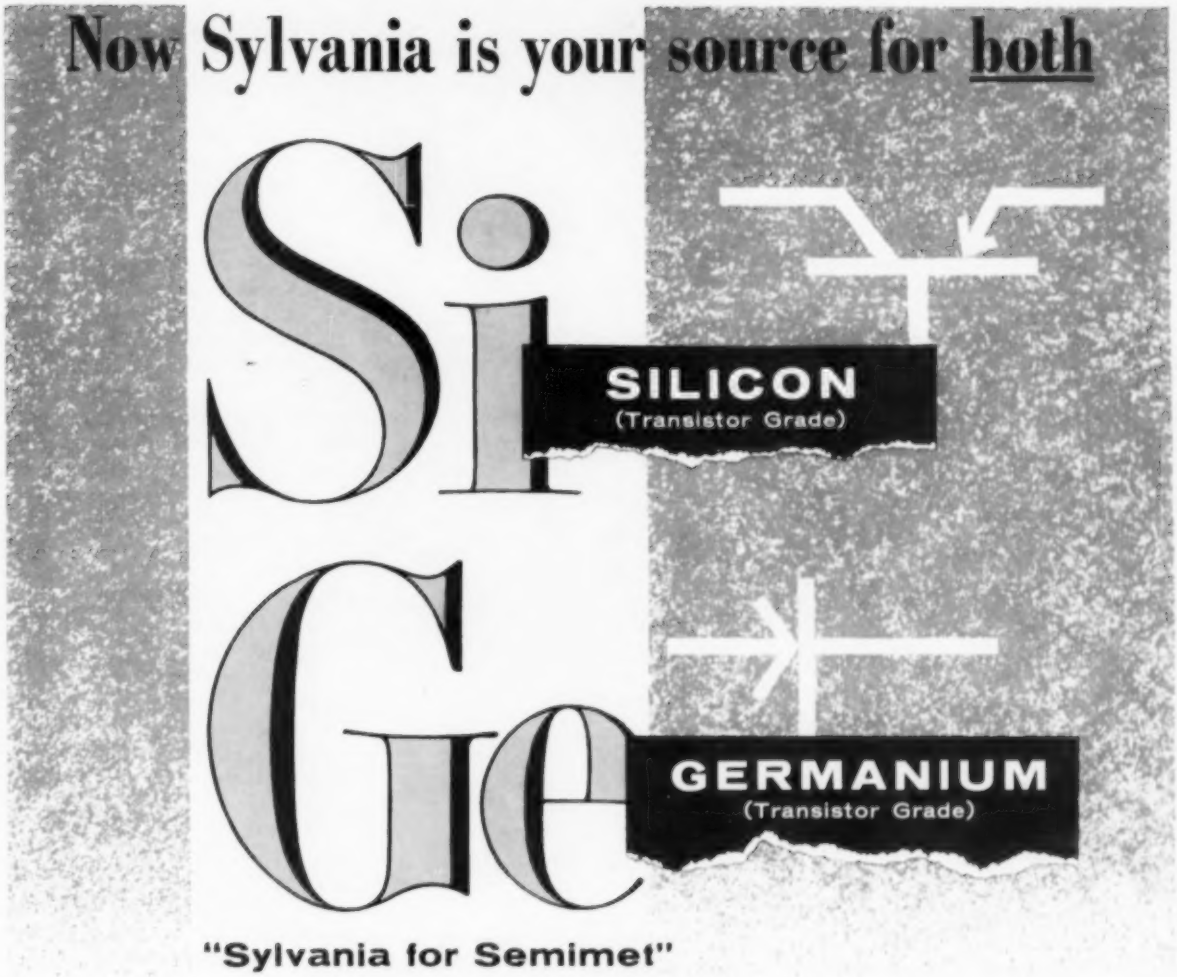

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Metastability . . .

the great stability of austenite at this temperature.

To determine whether the transformation to ferrite occurred at the tempering temperature or subsequently during cooling, a series of thermomagnetic tests were conducted to follow the change in magnetism of samples during treating and cooling. One sample which contained 25% ferrite after cold working and tempering at 1290° F. was reheated to 1290° F., and immediately after cooling to room temperature was found to have only 10% ferrite. After aging at room temperature about 24 hr., the ferrite content increased to 20%. In all samples tested, it was found that most of the ferrite formed during cooling, usually at temperatures below about 120° F.

Since it was found that more austenite transformed to ferrite in specimens cold worked at −300° F., it was assumed that material so treated would be nearer equilibrium than samples not cold worked or cold worked at room temperature. Such specimens might afford information about the stability of ferrite at tempering temperatures, so some were tempered for periods up to a month at 1290 and 1470° F. and up to two weeks at 1110° F. After one hour at each of these temperatures, more than half of the ferrite in each sample transformed to austenite. Longer times at the two higher temperatures resulted in some increase in ferrite content. This increase in the amount of ferrite observed between tempering periods of one hour to one week is due to ferrite which has formed on quenching as a result of carbide precipitation from austenite at the tempering temperature. The results of all of these groups of experiments indicated that the greater part of the ferrite detected after tempering had been formed on subsequent cooling to room temperature.

The transformation of austenite to ferrite occurs below 120° F. and isothermally at room temperature. The ferrite-to-austenite transformation on heating begins above 930° F., and is completed at 1290° F. The large quantities of ferrite observed after long sensitizing treatments at 1290 and 1470° F. are unstable at those temperatures.

E. C. Wright

Melting Practices for Stainless Steels

A report on the Electric Furnace Steel Conference held by the American Institute of Mining and Metallurgical Engineers at Pittsburgh, in December 1955.

THE INTRODUCTION of oxygen blowing in 1946 for making the low-carbon stainless alloys has been of great benefit. This subject was thoroughly reviewed at the recent Electric Furnace Steel Conference in Pittsburgh. Papers by R. B. Shaw, Allegheny Ludlum Steel Corp., D. J. Carney of South Works, U.S. Steel Corp., L. F. Weitzenkorn, Baltimore Works, Armco Steel Corp., and C. Yutmeyer, Midland Works, Crucible Steel Co. of America, were given.

Prior to the use of oxygen, most low-carbon stainless heats were made with virgin low-carbon ferrochromium and very little stainless steel scrap. Oxygen blowing for carbon reduction enabled the charging of large amounts of stainless scrap and higher-carbon ferrochromium, faster melting, and accurate control of silicon at tapping time. Now stainless heats have four distinct operating periods:

1. Melt down scrap and ferrochromium.
2. Blow oxygen to reduce carbon content to very low level (0.02 to 0.06%).
3. Reduce chromium oxides in the slag with silicon or aluminum.
4. Adjust the analysis and temperature of the bath.

Both carbon and chromium oxidize rapidly during the oxygen blowing stage and extensive study of this reaction by Hilty and his associates has enabled melters to estimate the ratio of chromium to carbon in the bath with fair accuracy. In blowing to reduce the carbon to 0.02 to 0.03%, most of the chromium in the bath is oxidized and enters the slag. Shaw's paper gives interesting charts showing the chromium-carbon relationship for various types of charge, blowing times and bath temperatures. The amount of oxygen blown varies with the type of charge and final analysis desired. For example, in a 50-ton heat the initial melt contained 15.5% Cr, 0.40% Si and 0.40% C. Assuming that 50% of the chromium is oxidized during the oxygen blow, the oxygen requirement for the carbon, silicon and chromium oxidation is calculated from the chemical equations. For this charge 3270 lb. of oxygen gas is needed and a further supply of 1027 lb. of oxygen comes from scale and iron ore charged. Oxygen is supplied at 45 lb. blown per minute for 60 min. The carbon content after this blow will be under 0.06%. If 304 L (less than 0.03% C) is to be made, it will be necessary to blow oxygen to a level under 0.025% and to oxidize up to 75% of the chromium in the charge.

In the third stage, after the carbon removal from the bath, the main object is to reduce the previously oxidized chromium from the slag; manganese, iron and phosphorus are also reduced from the slag in this period. Shaw states that in a 10-ton melt 90 to 96% of the chromium may be recovered from the slag while 80 to 90% recovery may be expected from 60 to 90-ton heats. In the reduction period additions of 75% sili-

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con ferrosilicon or ferrochrome silicon, crushed to suitable size, are mixed with dried lime and added to the oxidized furnace slag. The silicon reduces the iron, manganese, and chromium in that order from the slag, and the lime in proper amount holds the silica in the slag. The ratio of lime to silica is often two to one.

During this reduction period the metal just under the slag will increase in both chromium and silicon to such an extent that further reduction of chromium from the slag can be obtained only by thoroughly mixing the slag in the furnace or by tap-mixing. This involves tapping the whole heat from the furnace and then pouring the slag and metal back into the furnace.

Shaw prefers this practice and cites six advantages:

1. Furnace is emptied, which allows the bottom and banks to cool.
2. A check of the bottom and banks may be made before the finishing period.
3. Higher silicon in the bath may be tolerated because tap-mixing allows the silicon to react with reducible slag oxides.
4. Better slag-offs are obtained.
5. Deslagging after reduction period is more rapid.
6. The metal is cooled.

Tap-mixing is particularly effective on small heats (10 tons) but additional stirring is necessary on large heats (80 to 90 tons).

All material added after the slag-off should be dry because of hydrogen absorption by the bath, and slag volume should be small.

Hydrogen absorption is blamed for such defects as seams and blisters on finished products, and occasionally for bleeding ingots. Few data are available regarding actual hydrogen content of stainless melts but many melters take very special precautions to avoid hydrogen absorption by adding only dry materials, maintaining low silicon content or blowing with an inert gas such as nitrogen.

The difficulty of getting a large amount of chromium reduction on large heats (80 tons) as compared to small heats (10 tons) was also emphasized by D. J. Carney. It is attributed to the much larger slag volume, the reaction at the slag-metal interface and the need for thorough mixing of the slag and metal by rabbling or by tap-mixing. Lack of accurate information as to the weight and composition of the slag in large furnaces makes it difficult to determine the amount of reducing agent required. In addition, when large amounts of stainless scrap are charged, the reduction of phosphorus from the slag becomes troublesome because it begins to reduce during the later stages of chromic oxide reduction. Carney states: "The relatively complete reduction of phosphorus is becoming more and more of a problem in stainless melting — particularly with increased use of stainless steel scrap."

Silicon in the form of 75% ferrosilicon is the preferred reducing agent at most plants. Although aluminum or titanium may also be used, economic factors favor the use of silicon. As the silica forms, addition of sufficient quantities of lime or magnesia to hold the silica fixed in the slag aids in the chromic oxide

Stainless Melting . . .

reduction. None of the papers give any accurate figures as to what the lime-silica ratio should be at this stage. All authors state that the efficiency of the chromium recovery from the slag is much greater in basic-lined furnaces than in the acid-lined furnaces frequently used in stainless steel foundries. The efficiency of chromium recovery may be as low as 75% in large furnaces and as high as 95% in small ones.

Carney's paper emphasizes the stratification in the metal bath during the reduction period and points out the great importance of mixing the slag and metal bath. He shows that an 80-ton heat with a bath depth of 30 in. may have a chromium content on top that is 4.5% higher than at the bottom. Silicon content also varies from top to bottom.

E. C. WRIGHT

Dimensional Stability of Uranium

Excerpts from 19th Semiannual Report of the Atomic Energy Commission, January 1956.

Two of the most important problems associated with nuclear reactors are the corrosion and the dimensional instability of uranium. Since radioactive fission products must be prevented from entering the reactor system, the uranium fuel is usually clad in a protective jacket, whose effectiveness can be greatly impaired by dimensional changes in the uranium fuel during use. These changes also reduce the flow of the coolants as they pass through narrow channels past the fuel elements.

Dimensional changes in uranium can occur as a result of thermal cycling (repeated heating and cooling) or irradiation with neutrons. The mechanisms of these two effects differ, but both are based on the fact that at temperatures below 1220° F. the crystal structure of uranium has different physical properties in the three principal crystallographic directions.

Thermal Cycling – As an indication of thermal cycling effects, a polycrystalline rod of wrought uranium can extend to about six times its original length after prolonged cycling between 125 and 1100° F. This increase in length is accompanied by a decrease in diameter – essentially no change in volume.

Such effects occur particularly in wrought material because fabrication produces a preferred orientation. The greater the degree of preferred orientation, the greater the unidirectional growth upon thermal cycling.

A less drastic effect of thermal cycling, found particularly with cast uranium, is a roughening of the surface. However, if uranium is prepared, processed, or heat treated in such a way as to produce a very fine-grained structure with completely random orientation, neither axial growth nor surface roughening will occur upon thermal cycling. The addition of about 1% by weight of certain alloys can produce an indirect effect on thermal cycling by influencing grain size.

A single crystal of uranium does not undergo dimensional changes upon thermal cycling. Several mech-

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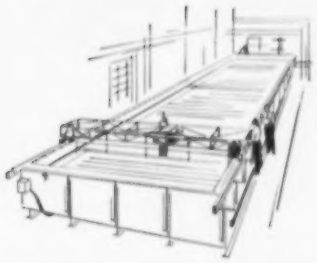

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Uranium . . .

anisms have been proposed, based on the interactions of grains in the polycrystalline metal and the anisotropy of uranium. A completely satisfactory theory for the phenomenon has not yet been developed and work on this continues.

Irradiation Effects – When a single crystal of uranium is irradiated by neutrons, it progressively elongates in the (010) crystallographic direction, shrinks in the (100) direction and remains unchanged in the (001) direction. At 212° F., this dimensional instability involves an extension of about 50% after sufficient irradiation to cause fission of 0.1% of the uranium atoms. The accompanying changes are negligible.

When polycrystalline rod samples with a high degree of preferred orientation are irradiated, the rate of growth may be as much as twice that of a single crystal; other things being equal, the rate of linear growth becomes greater with increasing cold work and also becomes greater with decreasing grain size.

Irradiation also can roughen the surface by the individual grains growing in different directions. This is most noticeable in coarse-grained samples.

A third type of dimensional change is due to an increase in volume, but is much smaller than irradiation or thermal cycling extension. (Increase in volume is on the order of 1% after 0.1% of the uranium atoms have fissioned, as compared to a possible 100% increase in length of a highly oriented polycrystalline sample for the same irradiation.) This change is thought to be due to internal porosity in addition to the extra volume of the fission product atoms, since the latter does not quantitatively account for the effect.

Several means of decreasing or eliminating the dimensional changes of uranium under irradiation have been developed. Fabrication techniques and heat treatments control the grain size and obtain a random orientation. Dimensional stability can also be greatly enhanced by additions of chromium, molybdenum, and zirconium alone and in combinations, which refine and randomize the grain structure through heat treatment. By using still greater amounts of these alloying elements, a crystal modifica-

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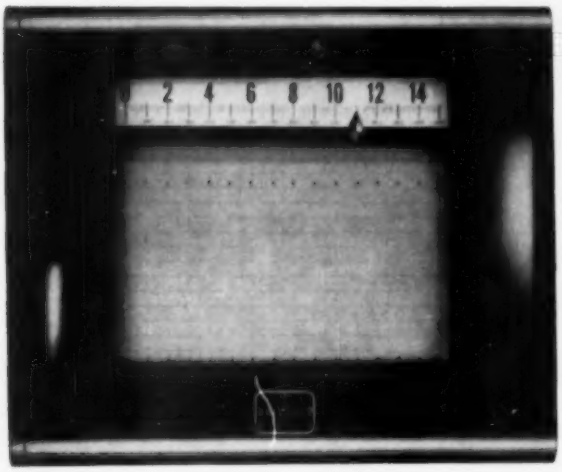

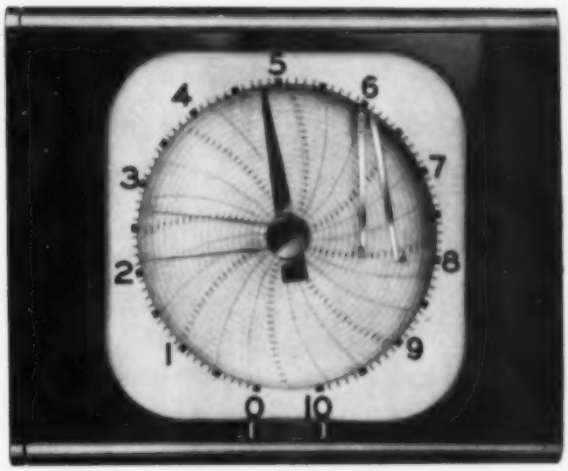

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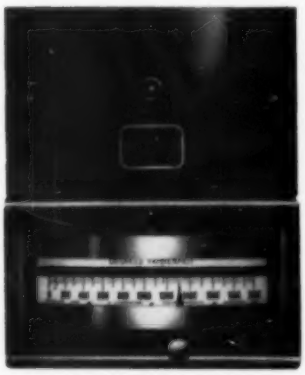

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Uranium . . .

tion can be obtained at room temperature which has excellent dimensional stability under irradiation.

Of the several mechanisms which have been advanced to explain the growth of uranium under irradiation, the most promising is based on the anisotropic diffusion of displaced atoms and vacancies produced in the lattice by irradiation and fission. The theory advances the idea that the displaced uranium atoms diffuse preferentially in the (010) lattice direction, thus causing growth in that direction.

This research is being conducted at many laboratories including the Argonne National Laboratory, Knolls Atomic Power Laboratory, Hanford Atomic Products Operation, Sylvania Electric Products Co., and North American Aviation, Inc.

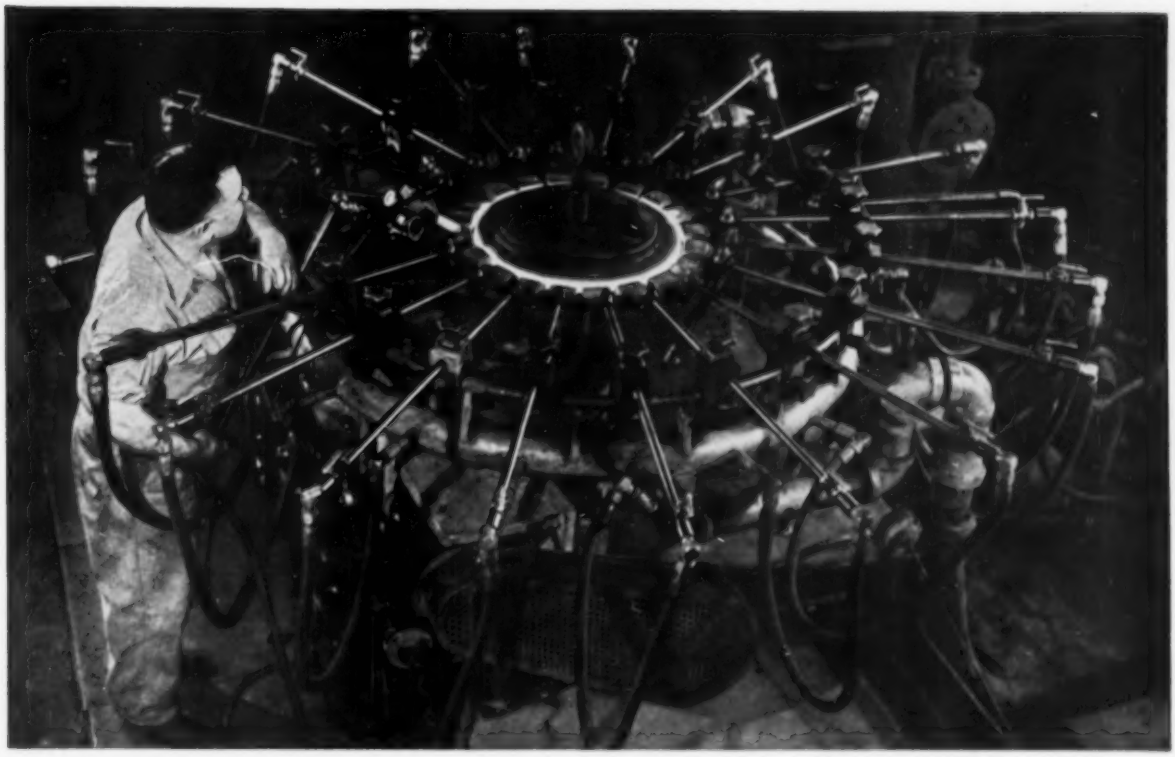
Low Temperature Irradiation — Some other byproducts of uranium researches are of interest.

The regular array of atoms in a crystal is thrown into disorder by fast particle bombardment, but much of the disorder is thermally unstable even at low temperatures. To understand the disordering process, it is necessary to examine both the nature of the unstable disorder and the annealing process in which order is restored.

To this end an experimental facility for the irradiation of solids at temperatures in the neighborhood of 20° K. (−253° C. or −420° F.) has been installed near the center of the graphite reactor at Oak Ridge. It consists of a chamber which is cooled by a helium refrigerator. The rate of disordering in specimens held in the reactor at this very low temperature of 20° K. has been measured for a number of metals and alloys, using the increase of electrical resistivity as an index of lattice expansion.

There is apparently a wide variation in both the disordering rate and the thermal stability of lattice disorder for the metals studied. The order of their increasing rates of resistivity change is gold, copper, brass, aluminum, nickel, cobalt, iron, zinc, Cu_3Au (disordered and ordered). Appreciable recovery follows warming the specimen to room temperature except for iron and zinc, which require higher temperatures.

E. E. T.



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Structure and Properties of White Iron

Digest of "The Structure and Mechanical Properties of White Irons", by W. J. Williams, *Metallurgia*, Vol. 52, Sept. 1955, p. 129-134.

THE BRITISH Cast Iron Research Association has found a serious scatter, as great as plus or minus 20%, in the mechanical properties of specimens cast from a single melt of white cast iron. A study of the microstructure of this alloy was undertaken to explain the reason for the difference.

Commercial white cast irons are usually hypo-eutectic, the structure showing primary dendrites that were originally austenite but transformed to pearlite on cooling through the critical point. With higher carbon there are fewer dendrites. The dendrites tend to be elongated perpendicular to a chilled face of a casting and are especially long and narrow in iron cast hot (2590° F.) and shorter and almost equiaxed in castings poured cold (2320° F.). The appearance of the fracture is not affected by this difference in the dendrites in hypo-eutectic white iron.

Hypereutectic white iron, in which the primary phase is cementite, has much coarser cementite needles when cast hot than when cast cold. Fractured surfaces show this difference, those of the iron cast cold appearing much finer. Thus the fracture appearance of white irons is governed by the carbide phase.

The scatter in mechanical test results from a single melt has made the investigation of the effects of composition on mechanical properties too difficult (apparently) to be attempted. It is not due to defects in specimens or testing procedure. It was observed, however, that the strengths were higher (by 50% in one instance) when the fractures were fine than when they were coarse, both kinds of fractures being obtained from the same iron cast in the same mold.

Macrostructures observed by oblique illumination showed the same differences as the fractures but the dendritic structures revealed by vertical illumination were similar for the specimens having both coarse and fine fractures respectively. This was because the pouring tempera-

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White Iron . . .

tures, which control the size of the dendrites, were the same. The appearance of the fractures, however, is controlled by the carbide, and micro-examination revealed a difference in the form of the eutectic. The major difference was the relatively discontinuous nature of the cementite particles in the specimen with the fine fracture, and their more diverse orientation. The eutectic probably started to solidify at a larger number of points in that specimen. The progress of the fracture in it would be retarded by more changes in direction.

G. F. Comstock

Errors in Hardness Testing

Digest of "The Errors Introduced Into Diamond Pyramid Hardness Testing by Tilting the Specimen", by T. O. Mulhearn and L. E. Samuels, *Journal* of the Iron and Steel Institute, Vol. 180, August 1955, p. 354 to 358.

Accurate Vickers hardness determinations require that the indenter axis be perpendicular to the surface of the specimen. Quantitative information on the relation between the degree of tilt of the specimen and the error in hardness reading is reported in this paper.

The alloys used for testing were selected to give a Vickers hardness range of 83 to 715. A commercial Vickers hardness tester was used and the test specimens were tilted with tapered blocks. Four of these blocks were tilted between 1° 58′ and 7° 57′. The direction of the tilt with reference to the diagonals of the indenter ("rotation angle") was also varied from 0 to 45°. Tests in the flat position were made adjacent to those in the tilted position. The diagonal lengths were all measured in the flat position.

On tests with zero rotation and about an 8° angle of tilt it was always found that the diagonal in the direction of slope is greater than its true diagonal while the other diagonal is always less. The larger diagonal is about 18% longer and the shorter one about 11% shorter than its true value. The average length of the two diagonals was thus greater by

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Hardness Testing . . .

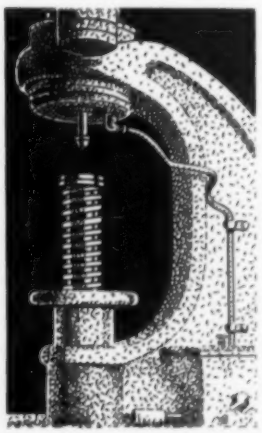
3 to 4% for tilted tests. Rotation of tilt direction, variation of indenting load and type of material did not increase this error.

From extensive testing the error in Vickers hardness number averaged about 0.7% with 2° tilt, 1.5% with 4°, 3.3% with 6° and 7% with 8°. The maximum error on a single test can exceed twice the average error so three to five readings are recommended to reduce the probable error. Errors exceeding 1% are unlikely if the tilt angle is 2° or less. A 3% error or more is likely if the angle of tilt exceeds 4°.

The best method for determining if a specimen has been tilted is to measure the segments of each diagonal from the interception. The ratio of the longer to the shorter segment is an indication of the angle of tilt. This ratio varies with both the tilt angle and the rotation angle. A given ratio indicates only that the tilt angle is within a certain range. For instance, if the ratio is less than 1.2, the tilt angle was less than 2°; for a ratio of 1.3, the tilt angle would have been 2 to 3°; for a ratio of 1.5, tilt angle of 3.3 to 4.3°; for a ratio of 2, tilt angle of 5.3 to 7.5°.

A tilt angle of 2° should be the maximum permissible in hardness testing. Although this would permit errors of 0.5 to 1%, a higher standard is too difficult to maintain. Measuring the diagonal-intercept ratios of the impressions is recommended for control because the asymmetry of an impression made with 2° tilt is very difficult to detect with the microscope.

G. F. COMSTOCK



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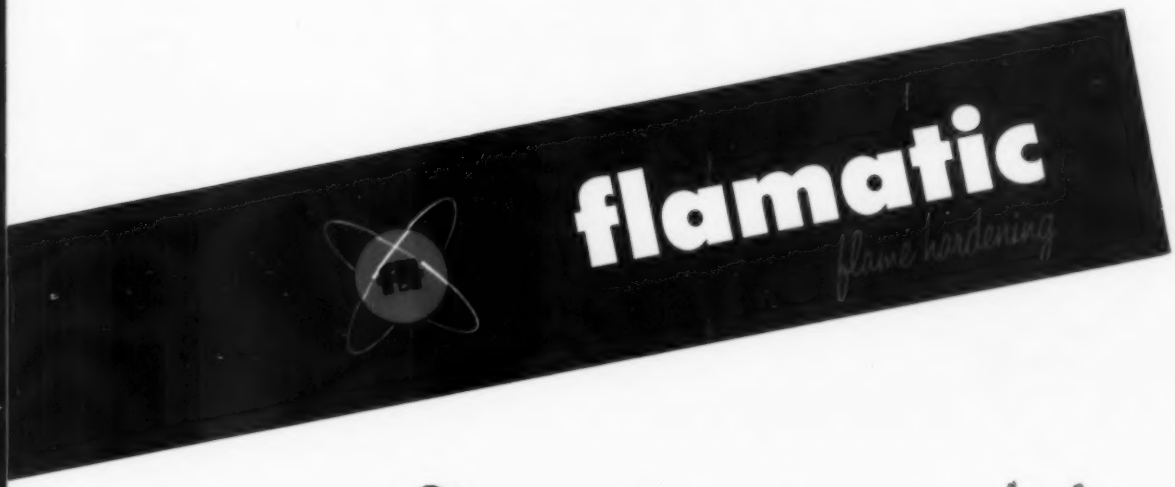

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Relation Between Impact and Tensile Strength at Low Temperatures

Digest of "Yield Behavior of Metals at Low Temperatures With Particular Reference to Some Carbon and Low-Alloy Steels", by H. F. Hall and R. W. Nichols, *Journal* of the Iron and Steel Institute, Vol. 180, August 1955, p. 329-336.

SELECTION of the best steel for service at low temperatures is difficult because the temperature at which brittle failure occurs depends upon how the stress is applied. If the stress is applied slowly and uniaxially, as in a tensile test, brittle failure occurs at a lower temperature than if a complex stress is applied suddenly as in a Charpy impact test. Unfortunately there appears to be no general correlation between the kinds of tests.

To determine whether such a relation exists, the tensile and impact properties of a wide variety of alloys from room temperature to −320° F. were studied by the Ministry of Supply Armament Research Laboratory in England. Included were copper, some aluminum alloys and carbon and alloy steels.

The yield strength of the steels increased with falling temperature (except for the 5% Ni steel for which it decreased from room temperature to −76° F.), but at a greater rate at the lower temperatures and for the lower-strength steels. The yield strength of copper and the aluminum alloys changed very little with temperature. The extension at the yield point was greater for most materials at lower temperatures than at room temperature.

The ultimate strength increased with falling temperatures for all materials except the heat treated 0.7% C steel below − 184° F., but in the steels the increase was less than that of the yield strength. In soft steel at low temperature the ultimate stress was below the upper yield stress.

The breaking stress, calculated from the reduced area after fracture, increased with falling temperature to a minimum at the temperature giving maximum elongation, and then decreased rapidly at lower temperatures. The breaking stress seems to be increased both by deformation and by falling temperature.

The reduction of area decreased

Low Temperatures . . .

with falling temperature for all the alloys except copper, for which it was constant. The steels showed a much greater drop in reduction of area below about −112° F. than at higher temperatures. In most of the steels the elongation rose slightly with falling temperature down to about −112° F., then fell sharply.

The Charpy curves for the steels showed the usual more or less sharp drop at a transition temperature; the Charpy value of the aluminum alloys decreased slightly, and that of copper increased with decreasing temperature. The temperatures at which the ductility curves for the steels showed a transition to low values were in general not the same as the impact transition temperatures.

Eight different test measurements were used to rate the brittleness of the steel. The three criteria evaluated by impact tests were the 50% cleavage-transition temperature, upper transition temperature, and the maximum energy value. The values used from tensile test results were the room-temperature reduction in area, reduction in area at −322° F., temperature for half the room-temperature reduction in area, room-temperature elongation and temperature of elongation drop. No two of these criteria placed the 15 different kinds of heat treated steels in the same order. The best correlation between a tensile property and the 50% cleavage-fracture transition temperature was shown by the temperature at which the reduction in area was half the room-temperature value.

The poor general correlation between the temperatures for brittleness in Charpy and in tensile tests is explained by the facts that temperature and stress conditions have different effects on the flow and fracture stresses for different materials. Materials for a given structure should be compared on the basis of the stress conditions required to produce brittle fracture at the lowest operating temperature, especially when this is far from the impact transition temperature.

A "dynamic factor", defined as the ratio of the static fracture stress at the Charpy transition temperature to the static 0.01% proof stress at the same temperature, was calculated for some of the steels to indicate the relative increase in flow and fracture stresses produced by the conditions of the Charpy tests at that temperature. These factors decreased with increasing proof stress and showed reasonable agreement with experiment. If such a factor were known for a structure the temperature for brittleness might be estimated from the tensile properties of the material over a range of temperatures.

G. F. Comstock

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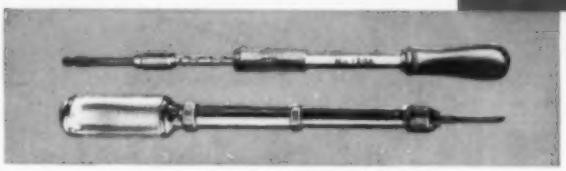

Important parts of these famous "YANKEE" Spiral Ratchet Screw Drivers and Automatic Push Drills completely and uniformly hardened for over 9 yrs. in the AGF† reciprocating furnace equipped with long life Nichrome muffles.

"Most important factor in maintaining low heat-hour costs is the extraordinary long life of the cast Nichrome muffles we use in our shaker hearth furnace," says W. W. Peterson, Vice Pres. of Yankee Tools Inc. Div. of Stanley Tools, Philadelphia, Pa., makers of FINE MECHANICS TOOLS.

A variety of small parts are hardened at 1550°-1600° in this furnace, which has been in continuous operation since 1946, on double shifts most of the time. Yet in nine years only two muffles were used—an average life of 4½ years each!

Peterson considers this performance so excellent that Nichrome castings are used throughout the "Yankee" heat treating department in the form of pots for cyanide and lead baths, where their performance is also outstanding. That's why "Yankee" Tools has been a Driver-Harris customer for over 27 years.

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Russian Theory for Creep Fracture

Digest of "Fracture of Metals During Creep", by V. S. Ivanova, *Metallovedenie i Obrabotka Metallov*, No. 1 1955, p. 19-26, and by I. A. Oding and V. S. Ivanova, *Doklady Akademii Nauk S.S.S.R.*, Vol. 103, 1955, p. 77-80.

AN INDICATION that vacancies (vacant lattice sites) play a roll in fracture during creep is the fact that the maximum energy of activation for the process of fracture is nearly the same as that for self diffusion, and it is widely accepted that vacancies play a dominant role in self diffusion. On this basis Greenwood proposed a theory that pictured the existing vacancies as migrating in the direction of the tensile stress and assembling at grain boundaries. This mechanism would account for the intercrystalline fracture that occurs in creep under low stress. Crussard refined Greenwood's theory by considering the interaction between stress fields and vacancies. He concluded that a crack parallel to the direction of stress would tend to collapse and become ineffective. A crack perpendicular to the direction of stress could increase in size under certain conditions and would cause fracture.

The purpose of the present papers by Ivanova and Oding was to develop this theory further and to suggest a mechanism that would explain the observed fracture behavior of metals undergoing creep.

As a basis for their considerations the present authors propose the following hypotheses:

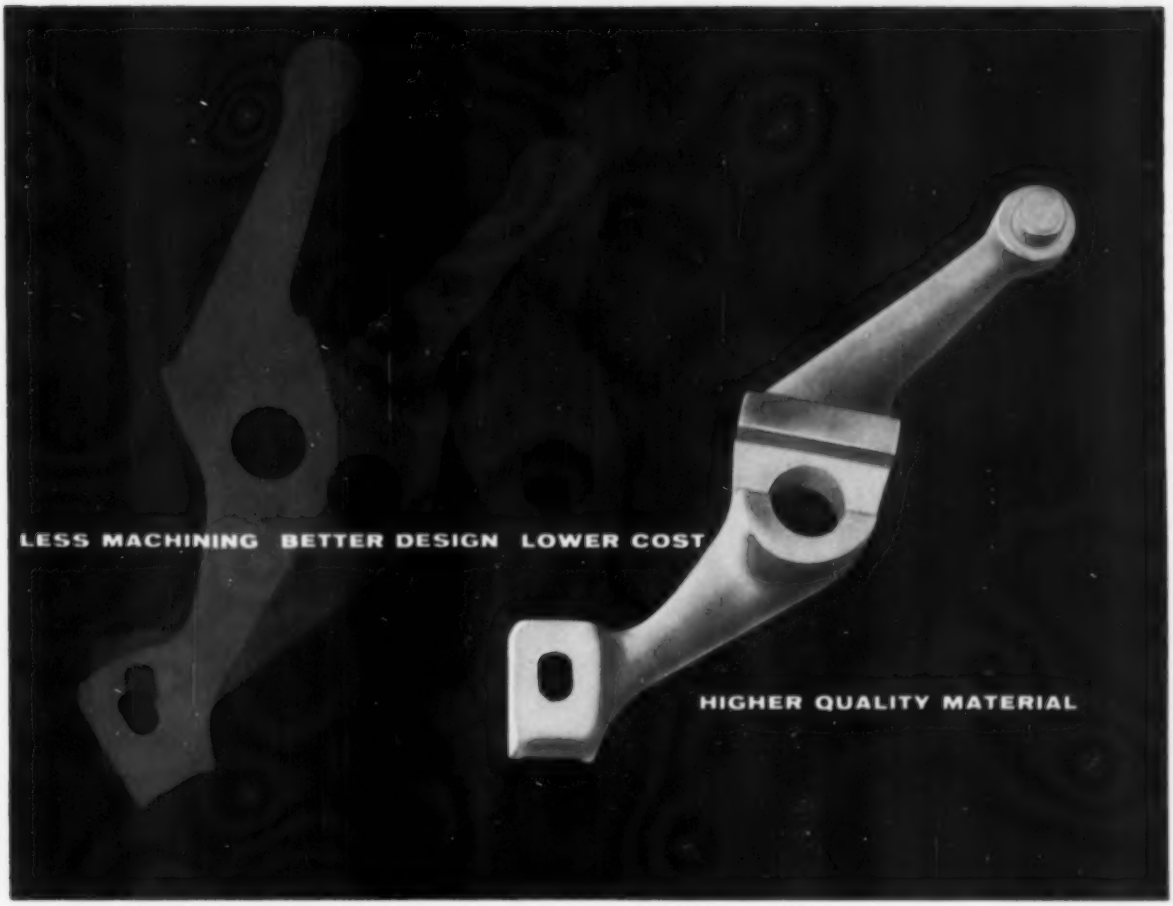
1. Vacancies will tend to move from regions of higher tensile stress to regions of lower tensile stress or of compressive stress. Since there is a stress field about a dislocation, the vacancies will tend to be concentrated in the regions of compressive stress.

2. Vacancies are essential if cracks are to form. However, the number of vacancies normally present is not sufficient for extensive crack formation. The additional vacancies needed are created during the formation and movement of dislocations, as when a dislocation meets an obstacle or leaves the slip plane. It follows from this reasoning that a metal could not fracture in high-temperature service if it did not undergo plastic deformation.

3. The nuclei for cracks are micropores or an equivalent accumulation of vacancies. The fact that micropores are present initially and develop further during plastic deformation has been shown by such experimental methods as forcing in colored liquids, dilatometry and X-ray diffraction.

These three hypotheses can be combined into the following visualization of the mechanism of fracture. An elliptical micropore is pictured with its long axis perpendicular to the applied stress. Stress-concentration effects produce tri-axial tension at the end of the long axis. At another point along this same axis, but some distance away from the micropore, the tensile stresses are somewhat lower. At the end of the short axis, there is tri-axial compression.

Plastic deformation occurs in the region of high tensile stresses and creates vacancies there. The vacancies tend to diffuse to the regions



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Creep Fracture . . .

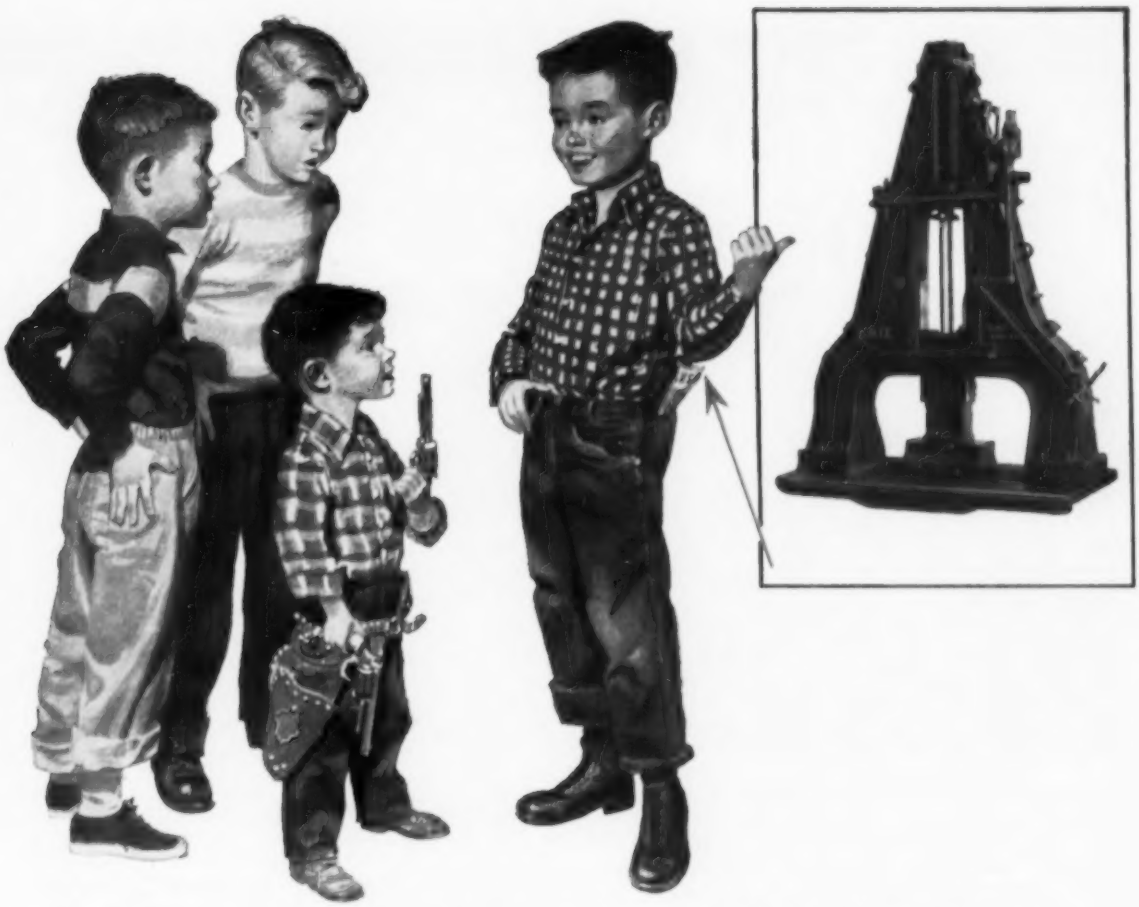
of lower stress. The flow of vacancies causes the micropore to assume a more rounded shape and also causes an elongation of the crack. If the rate of creation of vacancies at the end of the long axis exceeds the rate at which they leave there will be an accumulation that will increase the length of the crack. High rates are likely since the local act of deformation occurs rapidly.

Experimental evidence in support of this mechanism is supplied by the behavior of macroscopic notches. In long-time, high-temperature tests it is observed that a crack develops at the base of the notch or at a short distance in from the base.

This theory suggests a further revision of the estimate of the stage in creep at which cracking occurs. Hanson and Wheeler showed many years ago that cracking was occurring during the third stage of creep. Recently Kishkin proposed that cracks may start at the beginning of the second-stage creep, while the present theory would place the initiation of cracking in the first stage, even though present experimental methods have not detected the cracks. One support for this view is found in the fact that even short-time creep testing lowers the time for fracture in a subsequent long-time test.

An explanation can also be offered as to why cracking during creep tests is sometimes in the grain boundaries and sometimes through the grains. There is now conclusive experimental evidence that a significant fraction of the total creep occurs at the grain boundaries when the applied stress is low – that is, under conditions when intercrystalline fracture is observed. The localized deformation at grain boundaries will create vacancies here which will then accumulate to form cracks at the grain boundaries. Even the dislocations within the grains can move to the grain boundaries when the rate of deformation is low, and they will carry along the vacancies that are concentrated in the compression portion of the force field of each dislocation.

Transcrystalline fractures tend to occur for higher rates of deformation. Grain-boundary creep is less important under these conditions and the major part of the total creep is



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Creep Fracture . . .

accounted for by the dislocation-shear mechanism within the body of each grain. The slip lines produced under these conditions seem to be the areas in which vacancies accumulate and the subsequent cracks form. In fact it is found experimentally that crystalline fractures occur on slip planes.

Thus, crystalline and transcrystalline cracking of metals during creep are both caused by the same processes – diffusion of vacancies, accumulation of the vacancies into micropores, development of the micropores into cracks, and continued growth of these cracks until fracture occurs. A. G. GUY

Magnaflux Indications

Digest of "The Effect of Deoxidation Practice and Hot Work Reduction on the Occurrence of Magnaflux Indications in E4340 Type Steel", by A. F. Sprankle, presented at Philadelphia Technical Meeting of American Iron and Steel Institute, November 1955.

THE EFFECTS of deoxidation and hot reduction on Magnaflux indications in a 4340 alloy steel have been studied. Inclusion counts and deep etch patterns were compared with the Magnaflux results. Tests were made on two heats of steel that were deoxidized differently. Heat A received ferrosilicon, aluminum and calcium-silicon, while heat B received only ferrosilicon and aluminum. More aluminum was added to heat B than to heat A.

The first, middle and last two ingots from each 40-ton heat were rolled to 9½-in. square blooms. Samples were cut from the top after 20% discard and bottom after 5% discard, and forged into Magnaflux test bars of 4, 2, and 1-in. diameters. The remainders of all blooms were rolled into Magnaflux test bars of the same sizes. Magnaflux tests on the top ends were made only near the rolled or forged surface. All bottom samples were quartered lengthwise and one piece was machined round for Magnaflux testing. This was cut so the test would include metal from the center and surface of the rolled and forged bar.

The 5-in. Magnaflux samples were

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ultrasonic inspection news

40-FOOT ALUMINUM EXTRUSIONS INSPECTED UNDER WATER

How to inspect 40-foot, 1850-lb. aluminum extrusions for internal defects, prior to machining into helicopter blades? – Piasecki Helicopter Corp., Morton, Pa., required an immediate answer to this problem.

The solution was provided by Sperry Products' Commercial Testing Service. At Sperry's Danbury laboratory personnel and equipment were available, including a 100-foot tank which would permit ultrasonic immersion inspection of the huge extrusions.

To best meet your individual inspection requirements, Sperry Products Commercial Testing Service offers you complete ultrasonic testing laboratories in Danbury, Pittsburg and Chicago. Convenient in-your-plant inspection service is also available from these offices, as well as from Sperry Sales Offices in Boston, New York, Philadelphia, Atlanta, Houston and Los Angeles. Sperry Western, Inc., Lafayette, La., offers its specialized experience to the Oil Field Industry.

Actual inspection was accomplished with a Sperry UW Reflectoscope and a PH Positioner equipped to hold the search head at a constant distance from the section. These instruments were mounted on an electric car which also carried the operator. Straddling the immersion tank, the unit was capable of testing at speeds ranging from 2 feet to 32 feet per minute. To perform a complete inspection, covering the 31 inch width, including fillets, required a total of 117 longitudinal passes over each extrusion.

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Magnaflux Tests . . .

quenched, tempered and ground and were rated by the Allison methods in which the total number of streaks or indications are counted to give a figure for frequency. A second factor, severity, is also rated. It depends on the number of streaks in each of several length ranges. The regular Allison method does not count streaks shorter than ¾ in. but the M-Allison method counts streaks down to 1/32 in.

In this investigation the latter was used almost entirely for Magnaflux comparisons for forged and rolled bar sizes. By adding the ratings for all sizes of forged and rolled bars, the following summaries were obtained for the two heats: 437 frequency and 391 severity for heat A; 464 frequency and 498 severity for heat B. The 2-in. rolled samples accounted for the difference in severity even though a higher frequency number was shown for samples of heat A.

With respect to the ratings for ingot-top samples the two heats were almost alike with the following exceptions: 4-in. rolled samples from heat A were rated three times worse than B; 2-in. rolled samples from heat B were rated nearly three times worse than A; and 2-in. forged samples from heat A were rated nearly three times worse, in severity alone. In comparing the heats on the basis of the ratings for bottom samples, the only striking differences were that 1-in. forged bars rated A the worst, 4-in. forged bars rated B much worse, and 4-in. rolled bars rated B slightly worse. As a rule, the heat deoxidized with calcium-silicon gave slightly better Magnaflux ratings than the other, but no general conclusions in regard to deoxidation practice can be drawn from only two heats.

The forged samples gave better ratings than rolled samples near the surfaces of the bars with one exception. When quarter-section samples were compared, the rolled bars gave slightly better ratings. This is explained by assuming that irregularity of surface deformation in forging would draw out the inclusions near the surface into streaks not exactly parallel to a machined surface. Forging would give a deeper penetration of the hot work than rolling and thus

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Magnaflux Tests . . .

more streakiness of the inclusions near the center of a bar.

The 2-in. bars gave worse surface ratings than the 1 or 4-in. bars, possibly because the area was greater than the 1-in. bars and the hot working was greater (producing more streakiness) than in the 4-in. bars. The quarter-section samples showed little effect of section size. In heat B the 4-in. bars gave worse ratings, as might be expected from its size. The two heats were practically identical in cleanliness but the inclusion counts did not agree with the Magnaflux results in evaluating the heats.

Inclusion count ratings in heat B were slightly worse in rolled than in forged samples. This was not so in heat A. The average count for forged samples from heat A was slightly worse than B but for rolled samples the count from B was slightly worse than A. Heat B gave slightly better results in the etch tests than heat A, in disagreement again with the Magnaflux test. The etch tests were all satisfactory even though some porosity or deep etch markings existed near the centers of the top 4-in. samples. Photographs of etched sections from the 4-in. forgings are presented to illustrate these irregularities of the surface.

Finally, a computation was made of the relation between the average Magnaflux ratings for all bar sizes by the M-Allison method and the corresponding average ratings by the regular Allison method. The latter ratings averaged 30% for frequency with a range of 8 to 68% of the former or M-Allison and 50% for severity with a range of 16 to 93% of the M-Allison.

The published conclusions showed a definite partiality for heat A. Magnaflux ratings showing the maximum difference in favor of that heat were only selected from the forged 4-in. rounds. Had rolled 4-in. rounds been selected the difference would have been negligible with top and bottom ratings added together. It is falsely stated in the conclusions that heat A gave a "lower average inclusion count rating" than B. Also no mention is made of the superior etch test results for heat B. A publication with this type of conclusions can be very misleading.

G. F. Comstock

New Industrial Uses of Electropolishing

Digest of "Present Status of the Electropolishing of Steel and Special Alloys in Industry", by P. Jacquet and R. Mondon; paper sponsored by Société Francaise de Métallurgie and read before the Joint Metallurgical Societies Meeting in France, June 1955.

ELECTROPOLISHING was discovered some 25 years ago and has been widely used by research men and metallographers, but French industry was slow to investigate the possibility that a process eminently suitable for small samples could be used on large areas. Of recent years, however, it has been widely adopted; the many applications may fall in three classifications:

1. *Detection of Defects* – It has been found in the field of stainless steels that the only limitation of electropolishing is the quality of the semi-products. The defects observed and "removed" during the scarfing of billets and slabs appear immediately on the polished surfaces.

It is necessary that steel of "electropolished quality" be produced, as for example, by an English firm which is producing 17% chromium steel able to take a high-quality electropolish.

Quality checking is automatic for all electropolished parts. Notable instances are turbine blades of turbojet engines which not only are smoothed in 7 to 10 min. instead of 1 hr. in machine finishing, but structural heterogeneities and cracks are immediately discovered. In heat treated steel springs (polished after coiling) or piano-wire springs (wire polished previous to coiling) all metallurgical defects are exposed. Decarburized surface layers, a source of fatigue failures, are also eliminated.

2. *Substitution for Mechanical Polishing* – Given the necessary high quality of metal and reasonable smoothness of the semifinished part, it is very economical to produce a superior finish. It is also possible to control the treatment so as to dissolve a precise amount of metal, which is of importance in salvaging oversized parts.

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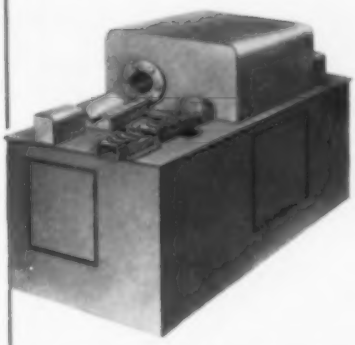

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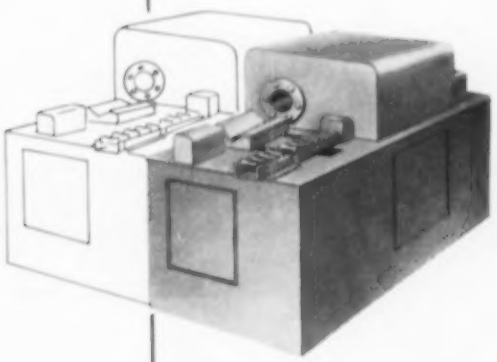

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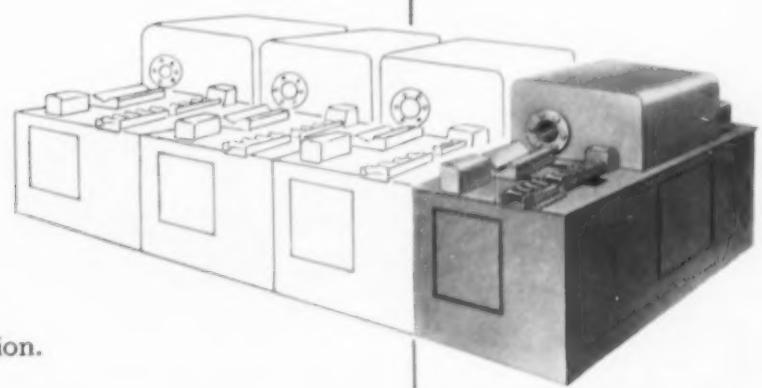

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Electro polishing . . .

which cannot be handled mechanically – for instance, zippers.

3. *Creation of a Surface With Special Properties* – Elimination of sharp asperities spectacularly improves the frictional properties and wear resistance of small gears.

For reasons still imperfectly understood electropolishing increases the capacity for plastic deformation of several metallic materials. Applied to the blanks, the treatment permits deep drawing of 25% chromium irons, as well as the spinning of molybdenum – operations which are practically impossible with the as-rolled, machine-polished or pickled sheets. Samples of pure chromium metal, brittle otherwise, have considerable tensile and bend ductilty after electropolishing.

Some jet engine components of the high-nickel Nimonics acquire a sufficiently changed surface during normal fabrication to affect their high-temperature corrosion resistance. Electrolytic polishing will restore the expected high durability.

Losses in fatigue resistance observed on electropolished laboratory samples do not appear in the parts in actual service (connecting-rods, injection pump springs, and valves) because other important factors are brought to bear, and because of the usual subsequent treatment which restores homogeneous compression stresses in the surface layers.

Whether it is due to a smoother surface or a surface with improved qualities it is a fact that 3-ft. driving gears for locomotives (which can be finished electrolytically in 30 min. rather than 30 hr. of machine grinding) have had superior service records over those conventionally machined, case hardened and ground.

Finally we are finding that parts electropolished before electroplating will accept the plate more readily and the plate itself will be more adherent and perhaps tougher. At any rate experience shows that parts so made have superior durability, and (since the final layer can be thinner) are less expensive.

Thus a review of some important applications in the field of steels and special alloys, most of which have stood the test, shows that electropolishing has gone considerably beyond its former status of a simple

Electropolishing . . .

ornamental finishing process. Experience shows that the process gives to metallic surfaces special properties, sometimes unexpected, which may lead to most varied applications. Without being a panacea, electropolishing has proved to be a remarkable tool in the hands of metallurgists, machine makers and mechanical engineers. E. E. T.

British Foundry Practice

Review of "Modern Foundry Practice", by E. D. Howard, Oldham Press Ltd., London, England, 384 p.

THIS BOOK deserves a place in every foundry library. It is up-to-date even though the format is entirely different from that to which we have become accustomed and the first reaction is that the illustrations are old fashioned.

It is a great mistake to consider that all foundry progress is to be found in the United States or Canada. Because of this, one can recommend "Modern Foundry Practice" to anyone who wishes to take a broad view of foundry operations and who desires to profit by the experience of others whose viewpoint may not always coincide with his own.

A very useful survey is contained in the introduction by V. C. Faulkner, former president of the Institute of British Foundrymen. It presents a precise picture of the foundry industry, both ferrous and nonferrous.

The first chapter deals with ferrous metals and discusses the effect of all of the usual so-called "impurities" in iron and steel and high-alloy castings. The next chapter deals with heat treatment in the foundry, for both ferrous and nonferrous alloys. The chapter on nonferrous alloys contains a modification of the copper-tin equilibrium diagram showing the progress of solidification of 10% Sn bronze under foundry conditions. The treatment of the subject of unsoundness, especially that due to absorbed gases, is up-to-date and lucid. One interesting example describes the remelting of the same

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Foundry Practice . . .

lot of gun metal 31 times. The last had just as high tensile strength and specific gravity and much greater elongation than the first.

It is in the section devoted to pattern equipment and the actual making of molds that this reviewer found the most unusual amount of detail. So much so, in fact, that for the first time he felt that, with this book as a reference, even he might qualify as a molder.

H. J. ROAST

Welding of Gas Turbines in England

Digest of "Inert-Gas Shielded-Arc Welding in the Gas-Turbine Industry" by G. C. Sandiford, R. T. Weatherstone, J. E. Hooper, K. H. McDonell and L. C. Camidge, *British Welding Journal*, Vol. 2, October 1955, p. 443-455.

A SMALL but specialized branch of the welding trade is represented in the British gas-turbine industry. Complex structures of the highest quality are fabricated from thin high-strength material probably to an extent and degree of finesse required by no other industries.

This paper attempts to review some of the shortcomings of materials, tooling, technique and equipment in the field of inert-gas shielded-arc welding, and to suggest probable future developments.

The need for fabricated components during the 1939 to 1945 period and the experience gained may be said to have overcome the prejudices of designers against the use of welded in place of bolted or riveted joints. This was also helped by the advance made in nondestructive testing and inspection, by which greater confidence in welding was obtained. By 1945, steels with strengths of up to 135,000 psi. after welding were quite generally used in conjunction with the metal-arc welding process. The advent of the turbojet engine resulted in a further quest to combine strength and lightness, and new design techniques were evolved.

The advance of fusion welding to inert-gas shielded-arc welding has allowed the introduction of a larger volume of light-alloy fabrication in

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Welding . . .

the design of the jet engine. Hitherto, the use of fusion welded light alloys was restricted by the need for flux, which in turn led to flux corrosion troubles where lap and inaccessible joints were made. Stronger aluminum alloys with strengths up to 36,000 psi. after welding by the inert-gas process have contributed to this quest for strength and lightness where applicable. Cowlings and air-system ducts, previously riveted, are now being welded. Not only is a smooth aerodynamically clean surface obtained, but the hazard of rivets falling into the engine compressor has been eliminated.

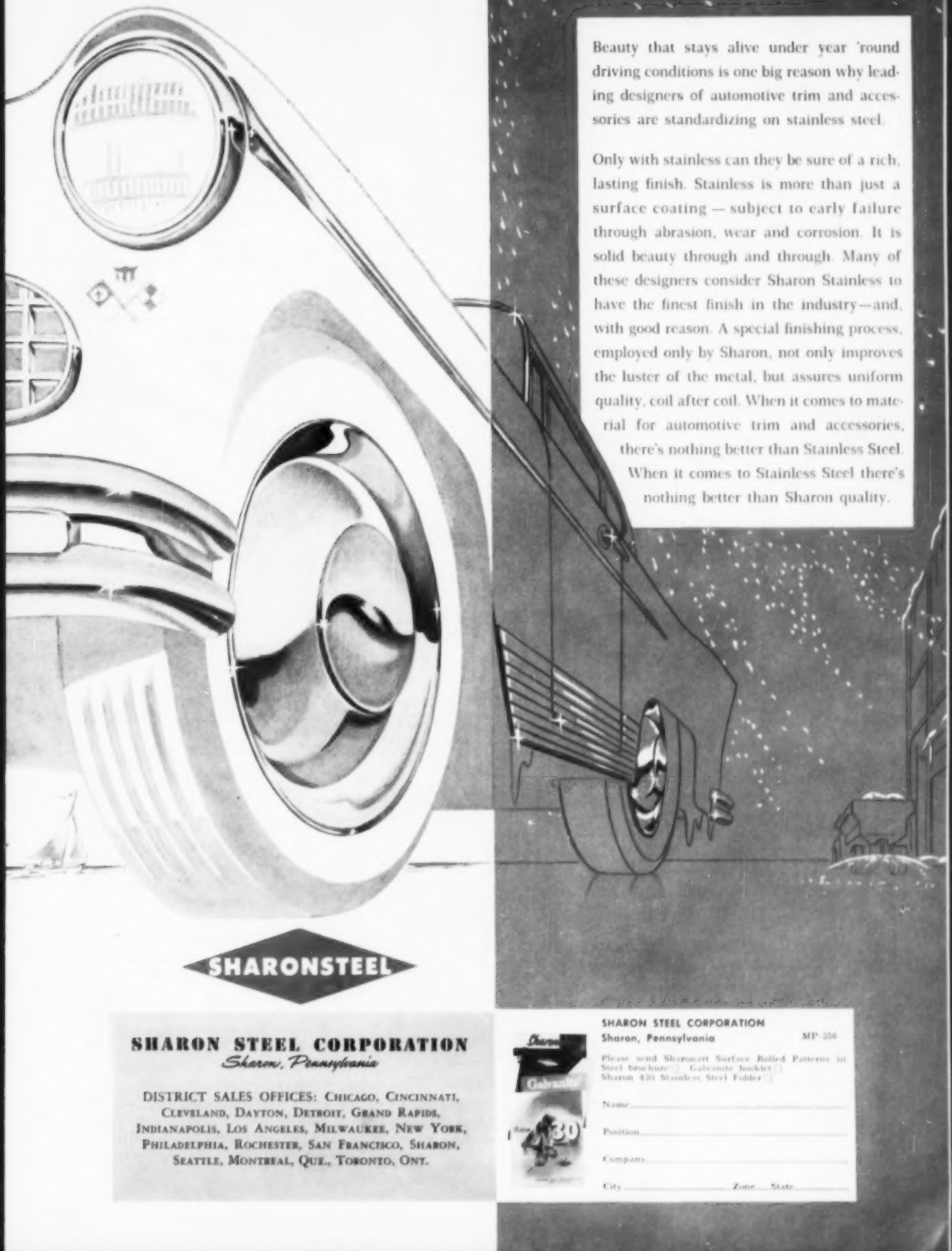
Welding in jet engines has been restricted to stationary components, but if high accuracy can be obtained in fabrication by mechanization, a new field of weight-saving will be open to the designer. Rotating assemblies, such as compressors and turbines, may be fabricated from high-strength sheet materials, using honeycomb or sandwich construction to give the desired modulus and stiffness without bulk. By such a construction, compressor and turbine blades and disks could be fabricated from sheet as thin as 0.018 in. with suitably accurate techniques.

New lightweight alloys capable of fabrication and with strengths up to 180,000 psi. at about 1100° F., or 335,000 psi. cold, will be required. During the next ten years titanium and titanium alloys may replace lower-strength steels and light alloys and will require all the ingenuity for fabrication that the welding industry has to offer.

With low-alloy steels, hardening near the weld can cause cracking under conditions of restraint. Where fully heat treated material is to be welded, a section near the weld will soften. Such materials are not attractive for design purposes unless they can be fully heat treated after welding. Since this involves quenching from the hardening temperature, they are not attractive from the production standpoint.

Manual argon-arc welding of Nimonic 75 has presented very little difficulty when the parts to be welded are not in the cold worked condition. Porosity and undercutting troubles have been encountered as well as irregular and severely oxi-

SHARON STAINLESS ASSURES LASTING BEAUTY



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Welding . . .

dized underbead welds on mechanical welding operations. These defects were apparently related to the speed of welding, inadequate shielding of the underbead, and the fit of the joint. They have now been virtually eliminated by the use of improved techniques.

The age hardening alloy Nimonic 80 has been welded either in the cast form or as forgings, and little difficulty, apart from minor ones associated with operator technique, has been experienced. On the other hand, it has been difficult to eliminate weld cracking troubles in Nimonic 90 where the joints are restrained to maintain a high degree of accuracy.

Entrapped oxide has been encountered in welding aluminum alloys because of failure to remove the oxide film at the underside of the joint, and incorrect manipulation of the filler wire. Another problem is excessive porosity in cast alloys. However, a good standard of welding can be achieved by careful attention to technique.

The main factor in weld quality assessment is the experience of the testing personnel and their knowledge of the principles of the inspection technique employed. The final decision is influenced by their appreciation of the conditions under which a given assembly was manufactured, and also its function in service. Thus, the interpretation of results obtained is, in many respects, primarily concerned with the prediction of the mechanical strength and likely behavior of the assembly in which certain defects may have been observed. It will be appreciated that there is a decided lack of information about the effect of defects on the strength of welds, particularly for thin materials, and the available data are insufficient for standardization.

Future trends in assessment of weld quality must include a "standardization scheme" to suit the particular needs of the jet-engine industry. This has been recognized by the National Gas-Turbine Collaboration Committee (Welding and Fabricated Structures Panel) which inaugurated a subcommittee to deal solely with the production of a document on quality control of welding.

DAN WHITE

HELIARC Cutting

TRADE-MARK

CUTS ALUMINUM AT SPEEDS UP TO 300 INCHES PER MINUTE

HELIARC cutting, a new process developed by LINDE, brings all the desired features of economical high-speed operations to the cutting of aluminum.

★ **Speeds never before possible:** Normal mechanized cutting speeds are 300 in. per min. in ¼-in. material, 125 in. per min. in ½-in. material, 75 in. per min. in ¾-in. material, and 50 in. per min. in 1-in. plate. If desired, lower speeds can be obtained by simply adjusting the controls.

★ **Straight lines, bevels, contours—no problem:** The new HELIARC cutting process can be used mechanically or manually. Both setups produce high-quality straight line cuts, bevels, circles, and shapes with revolutionary new speed and efficiency.

HELIARC cutting employs a high-temperature, high-velocity, constricted arc between a tungsten electrode and the piece to be cut. The concentrated, columnated energy of the arc stream melts and ejects a thin section of metal to form a kerf. The gas atmosphere (a combination of argon and hydrogen) prevents oxidation of the cut face.

Learn the details of how HELIARC cutting can help you increase production and cut operating costs. Call your LINDE Representative today.

Linde Air Products Company

A Division of Union Carbide and Carbon Corporation

30 East 42nd Street UCC New York 17, N. Y.

Offices in Other Principal Cities

In Canada: LINDE AIR PRODUCTS COMPANY

Division of Union Carbide Canada Limited, Toronto

"Heliarc" and "Linde" are registered trade-marks of Union Carbide and Carbon Corporation.

Linde

Trade-Mark

XIV

This is the fourteenth of a series of advertisements dealing with basic facts about alloy steels. Though much of the information is elementary, we believe it will be of interest to many in this field, including men of broad experience who may find it useful to review fundamentals from time to time.

Silicon - What It Is and What It Does in Alloy Steels

Silicon is a very abundant non-metallic element, one of the chief elementary constituents of the earth's crust. In the form of ferro-silicon, it is used by steelmakers as a deoxidizer and hardener in both alloy and carbon steels.

When the maximum silicon content is specified within the limits of 0.60 to 2.20 pct, the resulting steel is classed as a silicon alloy steel. However, all other standard alloy grades are specified to a range of 0.20 to 0.35 silicon for purposes of deoxidation. Silicon has several interesting effects, among them three that should be noted carefully: (1) it raises the critical temperature for heat-treatment; (2) as the amount is increased, it increases the susceptibility of steel to decarburization and graphitization; (3) combined with other alloying elements such as nickel, chromium, and tungsten, it promotes resistance to high temperature oxidation.

Silicon-Manganese Steels

Of the alloy steels relying heavily on silicon, one of the most important groups is the silicon-manganese series. As mentioned above, silicon is recognized as a deoxidizing agent, and a powerful one. Manganese behaves in the same manner but to a lesser degree.

Manganese exerts beneficial effects on the mechanical properties of heat-treated steel. Silicon as an alloy increases the strength. A properly balanced combination of the two elements produces a steel with unusually high strength, and with good ductility and shock-resistance.

Silicon-manganese steel has been widely used for the making of coil and leaf-type springs. It has also been used successfully for chisels, drift pins, punches, shear blades, mine bits, and other products that must be shock-resistant. It responds readily to oil-quenching, and when tempered at the correct temperature, it possesses not only shock-resistance but toughness and strength.

We invite you to consult with Bethlehem metallurgists whenever you wish to know more about silicon and its uses in steel. If you care to have them do so, these technicians will gladly suggest the proper analysis for your particular needs. Whatever it is, Bethlehem can furnish it, for Bethlehem makes all AISI standard alloy steels, as well as special-analysis steels and the full range of carbon grades.

If you would like to have a reprint of this advertisement, or of the entire series from I through XIV, please write to us, addressing your request to Publications Dept., Bethlehem Steel Company, Bethlehem, Pa.

BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

In ore clean-up buckets

FABRICATION SIMPLIFIED WITH USS "T-1" STEEL

(and weight reduced more than ½ ton)

This photo courtesy of Blaw-Knox Company.

HALF AS THICK! In the trays for giant ore clean-up buckets, 1¼" USS "T-1" Steel Plate, with a yield strength of 90,000 psi., replaces cast trays which were as much as 2½" thick. The new buckets—lighter in weight by more than half a ton — and expected to outperform the heavy cast trays, will be used at United States Steel's South Works.

• The trays of ore clean-up buckets must have phenomenal shock and abrasion resistance to hold up under constant scraping and scouring along the steel bottoms of ore boats. They are commonly made of heavy steel castings. But recently, Blaw-Knox Company, Pittsburgh, Pa., *fabricated* trays for several new buckets from USS "T-1" Steel Plate. This amazing new alloy steel assures the needed strength and durability, plus important fabricating advantages.

LESS WEIGHT — LESS EXPENSE

Biggest single advantage of fabricating from "T-1" Steel Plate is less weight. New trays weigh only 4,021 pounds each, compared to 5,068 pounds for comparable cast manganese steel trays. Thus, "T-1" decreases the weight of the bucket and reduces shipping and handling costs.

What's more, fabrication from "T-1" simplified the building of these huge buckets. It eliminated the expensive patterns needed for cast trays. Because "T-1" has tremendous resistance to impact abuse and abrasion, it is expected that it will outperform previously used materials.

For these ore buckets, "T-1" Steel is flame-cut to size, *cold formed* in a 1,250-ton press, drilled and then riveted to the bucket shell. "T-1" also can be welded—without pre- or post-heating. Because of its unusual combination of properties, it is cutting costs in many rugged applications.

LOOK AROUND YOUR SHOP

In your own equipment, or in the products you make for others—wherever you would like to increase service life . . . wherever you would like to reduce fabricating costs of heavy-duty parts—look into the possibility of using "T-1" Steel. Competent technical advice is always available, of course — free of charge — from United States Steel. Write, wire, or phone for complete information. United States Steel, Room 5215, Pittsburgh 30, Pa.

UNITED STATES STEEL CORPORATION, PITTSBURGH
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA.
UNITED STATES STEEL SUPPLY DIVISION,
WAREHOUSE DISTRIBUTORS, COAST-TO-COAST
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS "T-1" CONSTRUCTIONAL ALLOY STEEL

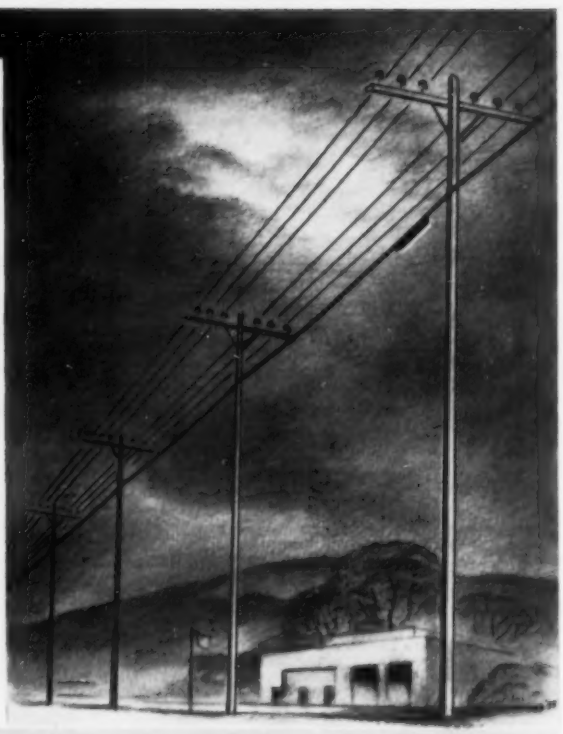
USS

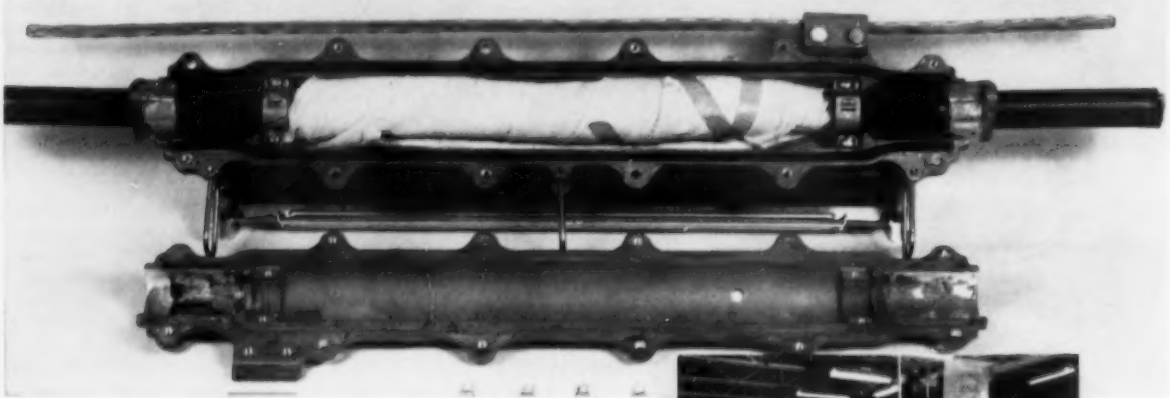
UNITED STATES STEEL

these die castings had to be

LEAK-PROOF

In critical communications work, after a splice has been made on a telephone aerial distribution cable, the splice must be protected against moisture. To accomplish this, Western Electric Company is producing a die cast aluminum splice case, basically cylindrical, the two halves of which are bolted together with suitable gasketing material. The housing thus forms a weather-tight seal capable of withstanding internal gas pressure of 10 P. S. I.





These parts are run at New England Die Casting Company. Many other parts, meeting the same exacting requirements of the most critical industrial applications, are run in the all-Lester-shop.

Mr. Charles W. Ohse, President of New England Die Casting, knows that he can offer his customers the best in die castings because he has the best in die casting machines—Lesters.

If you want additional information about Lester machines just drop us a line. And ask to receive the Lester-Phoenix house organ, "The Lester Press."

LESTER DIE CASTING MACHINES

REPRESENTATIVES

New York . . . . Steven F. Krould
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Chicago . . . . . J. J. Schmidt
Cleveland . . . . . Don Williams
Coral Gables . Morton Machinery Sales
Cincinnati . . . Index Machinery Corp.
Los Angeles . . . . Machinery Sales Co.
St. Louis, Milwaukee . . . . . A. B. Geers

FOREIGN

Toronto, Canada . A. R. Williams Mach. Co., Ltd.
Sydney, Australia . . . Scott & Holladay, Ltd.
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Stockholm, Sweden . . Aktiebolaget Servus
Basle, Switzerland . . . . . Hermann Walti

distributed by LESTER-PHOENIX, INC., 2619-X CHURCH ST. • CLEVELAND 13, OHIO

one must set the example

. . . and with high speed steel it's REX

It's a real satisfaction when you set the example by what you make . . . when it becomes a *standard for comparison*. That's why Crucible is proud to have kept REX high speed steel tops in its class for so many years.

But don't take our word for REX's superiority. Try it on your own work. Compare its structure, finish, hardenability, carbide distribution and general uniformity. You'll see for yourself why it's the *standard* wherever high speed steels are used.

Remember, REX is made only by Crucible. So call for REX at your nearby Crucible warehouse, or for quick mill delivery — *Crucible Steel Company of America, Henry W. Oliver Building, Pittsburgh 22, Pa.*

CRUCIBLE first name in special purpose steels

Crucible Steel Company of America

When you use Houghton Salts . . .

WE ROLL UP OUR SLEEVES!

When you use Houghton salts, you get lots more than the product itself—you get Houghton's years of heat treating experience, Houghton's extensive research facilities, Houghton's team of heat treating specialists, and Houghton's on-the-job service. You get the *results* you want, no matter how tough the job.

The Houghton Man stands ready to roll up his sleeves and go to work for you. He'll recommend the Salt Bath you need—for tempering, martempering, annealing, quenching, carburizing, nitriding, normalizing or hardening of metals. If the job presents unusual problems, he'll stick right with it till you are satisfied.

There's nothing like a trial in your own plant. Your Houghton Man will be glad to arrange it. Meanwhile, if you don't have our latest "Liquid Salt Baths" book, write to E. F. Houghton & Co., 303 West Lehigh Ave., Philadelphia 33, Pa.

LIQUID SALT BATHS . . . products of

E. F. HOUGHTON & CO.

PHILADELPHIA · CHICAGO · DETROIT · SAN FRANCISCO

Ready to give you on-the-job service . . .

New improvement in Chromium Plate

New plastisol sprays coating 50 mils thick

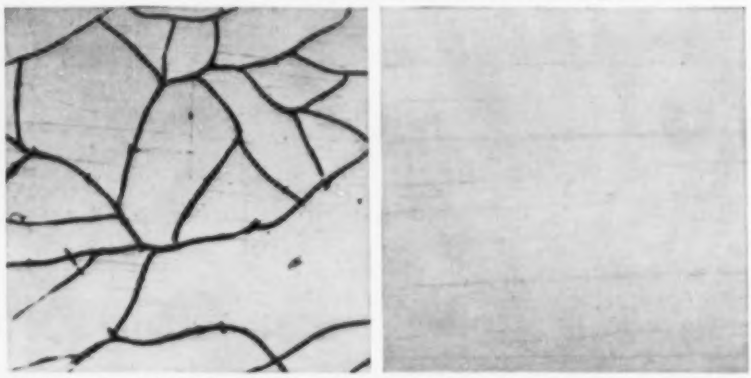
Unichrome "Super 5300" Coating delivers the full solids content of vinyl plastisol right through a spray gun. It permits a pore-free 50 mil coat to be obtained in just one application on flat or irregularly shaped surfaces.

Single or multiple coats of this material amount to a vinyl "sheet" material, but *without* any seams or joints where corrosives might penetrate. "Super 5300" shrugs off strong acids, caustics, water, salt solutions and other corrosives. Its heavy duty protection often permits use of ordinary metals in place of costly alloys. Write in for more data.

Good masking with non-cyanide copper plating

Metals engineers have long made good use of Unichrome Pyrophosphate Copper Plating Process for stopping off areas in nitriding and carburizing. Because of the density and fine grain of the deposit, dependable masking is secured with a thinner plate, saving time, money and copper. Bulletin CU-3 tells more.

Crack-Free Chromium Deposits give unique protection to parts



(Left) Surface view of etched ordinary chromium surface, enlarged about 75X, shows typical network of cracks. (Right) Etched Crack-Free Chromium surface shows none of this. Steel parts are therefore securely protected from rust.

Electrodeposits become continuous surfaces as thickness increases and porosity vanishes . . . except for *ordinary* chromium plate. Something else happens. Cracks develop as the chromium deposit builds up. Through these defects, corrosives reach the underlying metal. Unichrome Crack-Free Chromium eliminates these structural imperfections.

Comparative tests have demonstrated that Crack-Free Chromium makes a tremendous difference in corrosion protection.

At 110° F, and 100% relative humidity, only .0003" of Unichrome Crack-Free Chromium protected steel from rust for over 1000 hours. With ordinary chromium, identical parts were rust-covered in just *days*. In testing protection of .0005" of chromium plate in salt spray for 100 hours, one user found steel shafts protected with Crack-Free Chromium unaffected; while shafts with ordinary chromium were enveloped with rust.

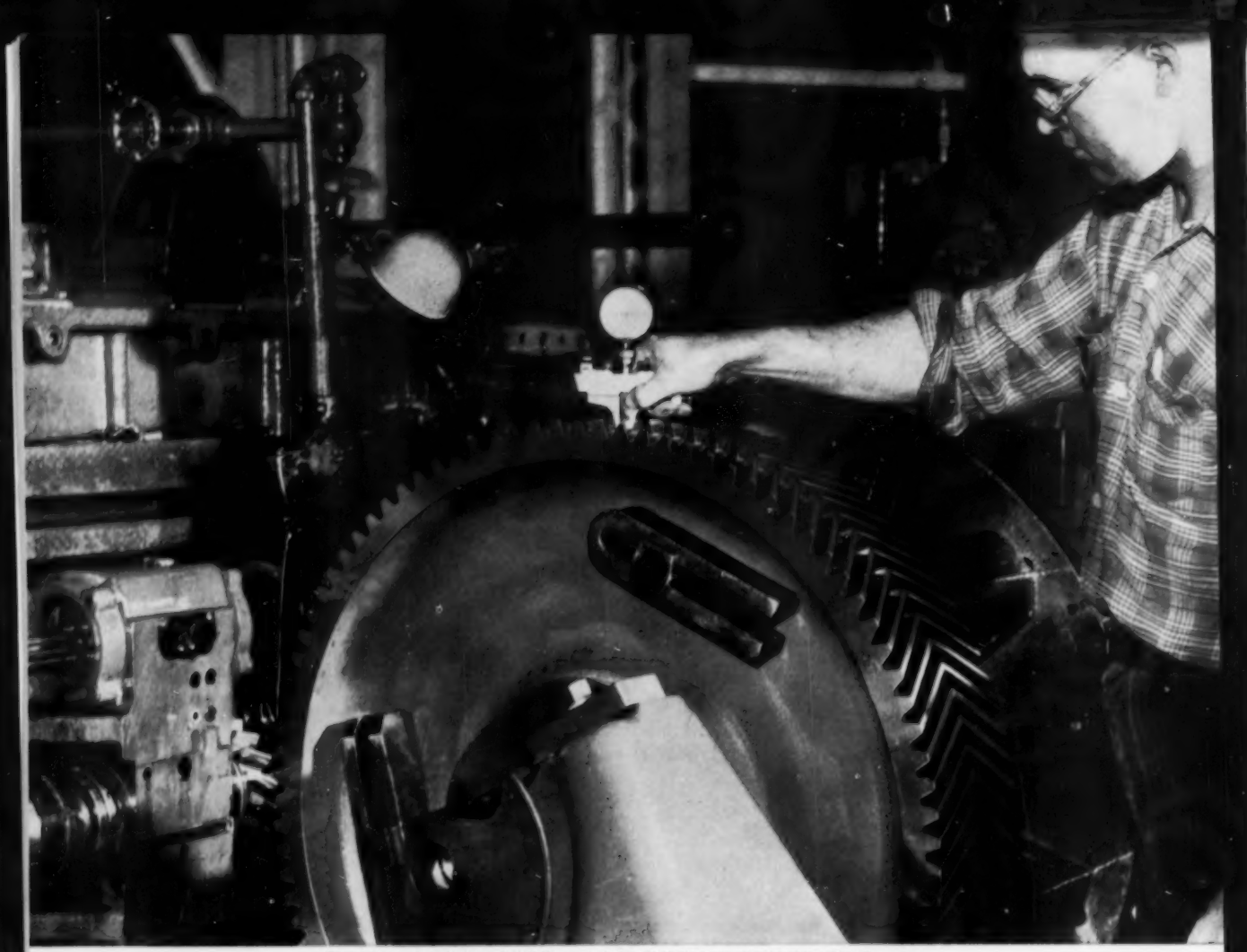
WHERE TO USE

That is a question best answered by product designers. Knowledge of the complete advantages may suggest many uses. Crack-Free Chromium also offers:

1. Wear-resistance, hardness, and low friction.
2. Improved non-galling, non-seizing properties.
3. A more ductile deposit, resistance to thermal shock and better protection at elevated temperatures. Good impact resistance.
4. Excellent leveling action which helps cover surface imperfections. Also easier, faster grinding, if required.
5. Protecting the base metal without undercoats, Crack-Free Chromium can be used directly on steel or zinc base die castings for many applications.

APPEARANCE

A satin, matte finish, Crack-Free Chromium can be left as is, or readily buffed to high luster. Ask for recommendations, or send for Bulletin CFC-1.



Checking teeth pitch on 32" O.D. gear at the Philadelphia plant of Link-Belt Company.

speed up machining, extend cutter life with Standard Steel forged gear blanks

By switching to Standard Steel forged blanks for the helical and herringbone gears used in their enclosed drive units, the Philadelphia plant of Link-Belt Company has speeded up machining time and lengthened cutter life substantially. That's because:

- Dimensional tolerances are closer, so all gear blanks of the same size can be machined on a single setup.
- Standard Steel forged blanks have no blow holes, porosity or non-metallic inclusions, so finish turning, facing, boring and hobbing can be done faster.
- High speed cutters last much longer because these forgings have a more uniform internal structure.

Link-Belt's experience in reducing costs is typical of hundreds of other manufacturers. When you specify Standard Steel forgings, you get a product that is quality-controlled from start to finish. We produce our own acid open hearth steel, heat treating and tempering it carefully. Finished forgings are carefully inspected and checked to assure meeting customer specifications.

In addition to gear blanks, Standard Steel can furnish you with rings, flanges, shafts, wheels and special shapes—and furnish them *fast*. Next time you need forgings, get our quotation first. For a copy of our new bulletin, write us at Burnham, Pennsylvania.

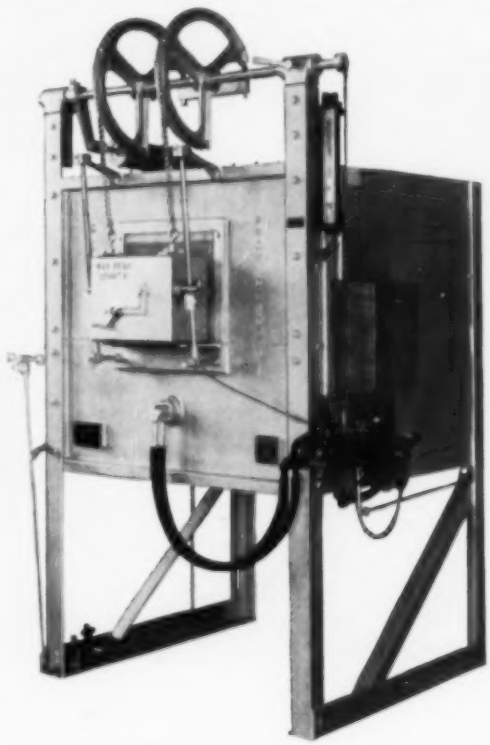
BALDWIN BLH LIMA-HAMILTON

STANDARD STEEL WORKS DIVISION

BALDWIN-LIMA-HAMILTON

DIVISIONS: Austin-Western • Eddystone • Lima Electronics & Instrumentation • Hamilton • Pelton • Loewy-Hydropress • Madsen

GLOBAR® *heating elements in this* **HAYES** *hardening furnace help turn out* **TOP QUALITY PRODUCTS**



● This controlled-atmosphere steel hardening furnace is equipped with GLOBAR® Silicon Carbide Heating Elements side mounted above and below the hearth level. Designed and built by C. I. Hayes, Inc., Cranston, Rhode Island.

DESIGNED FOR CONTINUOUS OPERATION at the 2200°-2400°F. range, this modern electric furnace depends on GLOBAR® Heating Elements for uniform, controlled heat needed in hardening high speed steels on a production basis. Accurately-controlled electric heat assures cleaner treated parts...reduces rejects due to faulty heating. Quality of the finished product goes up, while costs go down.

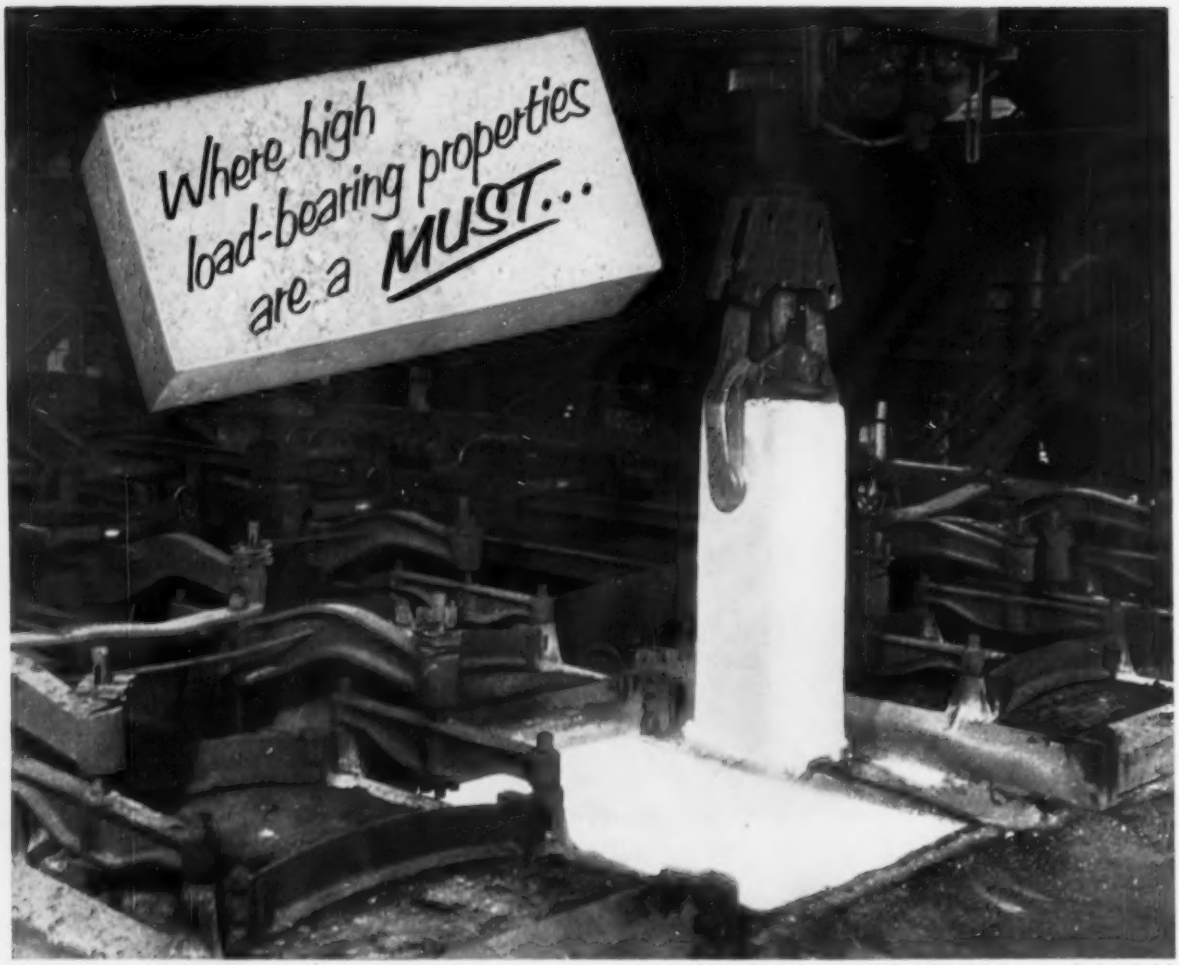
YOUR BEST CHOICE... GLOBAR ...as the source of heat in industrial electric furnaces for heat treating, brazing, sintering, annealing, and other industrial heating operations. GLOBAR engineers will be glad to evaluate your heating requirements, without obligation. Write The Carborundum Company, Dept. MP 87-64, Niagara Falls, New York.

FREE CATALOG... gives detailed physical and electrical characteristics, of GLOBAR® Silicon Carbide Heating Elements. Also mounting and control recommendations. Write for Bulletin "H".

GLOBAR® *Heating Elements*

by **CARBORUNDUM**
REGISTERED TRADE MARK

87-64



In soaking pits, Johns-Manville Sil-O-Cel C-22 Insulating Brick provide outstanding performance as back-up insulation.

Specify

Johns-Manville SIL-O-CEL C-22 Insulating Brick

the diatomaceous silica brick that retains its high cold crushing strength of 700 psi throughout normal service range

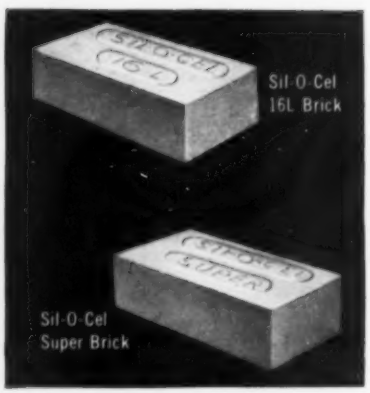
Because of its exceptional strength Sil-O-Cel C-22 Insulating Brick has gained wide acceptance as an all-purpose insulating brick. It is especially recommended for soaking pits, open hearth bottoms, slab heating furnaces, hot blast stoves, coke ovens and other high temperature equipment.

Millions of microscopic cells provide Sil-O-Cel C-22 brick with excellent heat resistance up to 2000F. It has a thermal conductivity of only 1.88 Btu in/sq ft/F/hr at 1000F mean temperature. In addition, with a density of 38 lb/cu ft, it is light and easy to handle.

For direct exposure or back-up to 1600F, use Sil-O-Cel 16L Insulating Brick. This newest member of the J-M diatomaceous silica insulating brick family has *less than 0.1% reversible thermal expansion at 1600F.* Conductivity is 1.07 Btu in/sq ft/F/hr at 1000F mean temperature with a density of 33-35 lb/cu ft. Cold crushing strength is 350 psi. Sil-O-Cel 16L serves equally well as back-up insulation or exposed refractory lining.

For back-up at higher temperatures, specify Sil-O-Cel® Super Insulating Brick with an unusually high temperature limit of 2500F.

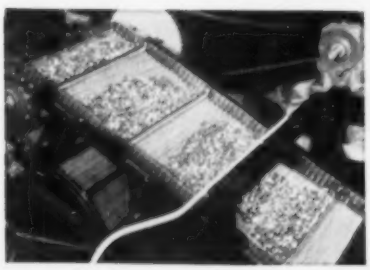
Write today for further information on Sil-O-Cel Insulating Brick and Insulating Fire Brick. Ask for Brochure IN-115A. Address Johns-Manville, Box 60, New York 16, N. Y. In Canada, 565 Lakeshore Road East, Port Credit, Ontario.

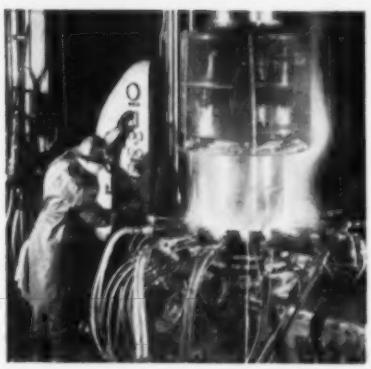


Johns-Manville *first in* **INSULATION**

MATERIALS · ENGINEERING · APPLICATION

You need MORE than these to Heat Treat Metals!





The science of heat treating has become of vital importance to many manufacturing operations. Without the radical improvements of the properties and characteristics achieved in metals and alloys by heat treating, many of the nation's most important products could not be made.

To perform the appropriate type of heat treatment, such as annealing, normalizing, quenching, tempering, carburizing, controlled atmosphere hardening, stress relieving and others requires specialized, intricate, and expensive equipment such as is illustrated here.

But *more* than such equipment is needed. The most modern and highly specialized equipment is useless without the correct combination of operational skill and technical experience that has been developed over years of practical operating practice. Equipment and materials are important, but the *essential* factor in heat treating operations of all kinds is the human touch and the practiced hand.

The members of the Metal Treating Institute listed here are the recognized leaders of the commercial heat treating industry. They are specialists possessing the equipment, the technical skill, the years of experience, and the personnel with which to solve your heat treating problems all under one roof.

When you need complete heat treating services or want consultation concerning heat treating or engineering or design problems, write any of the companies listed. All inquiries will receive prompt attention.

WRITE FOR A COPY OF A BOOKLET "A REVIEW OF SALT BATH CARBURIZING".

THERE'S A HEAT TREATING SPECIALIST NEAR YOUR PLANT

Ace Metal Treating Corp.
Elizabeth, New Jersey
Allied Metal Treating Corp.
Kenosha, Manitowoc, Racine, Wisconsin
Anderson Steel Treating Co.
Detroit, Michigan
B. & W. Precision Heat Treating Co.
Kitchener, Ontario, Canada
Benedict-Miller, Inc.
Lyndhurst, New Jersey
Bennett Heat Treating Co., Inc.
Newark 3, New Jersey
Commercial Metal Treating, Inc.
Bridgeport, Conn.
Cook Heat Treating Co. of Texas
Houston 11, Texas
The Dayton Forging & Heat Treating Co.
Dayton 3, Ohio
Drever Company
Philadelphia 33, Pennsylvania
Groenman Steel Treating Company
Worcester 5, Massachusetts
Fred Heinzelman & Sons
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MTI — MASTER CRAFTSMEN — METAL TREATING INSTITUTE

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Hollywood Heat Treating Co.
Los Angeles 38, California
L-R Heat Treating Company
Newark, New Jersey
The Lakeside Steel Improvement Co.
Cleveland 14, Ohio
Metallurgical, Inc.
Minneapolis 14, Minnesota
Metallurgical, Inc.
Kansas City 8, Missouri
Metlab Company
Philadelphia 18, Pennsylvania

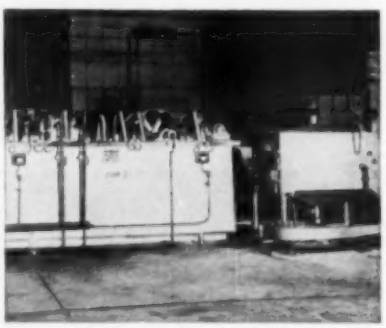
Metro Heat Treat Co.
New York 13, New York & Ridgefield, N. J.
New England Metallurgical Corp.
South Boston 27, Massachusetts
Paulo Products Company
St. Louis 10, Missouri
Pittsburgh Commercial Heat Treating Co.
Pittsburgh 1, Pennsylvania
The Queen City Steel Treating Co.
Cincinnati 25, Ohio
J. W. Rex Company
Lansdale, Pennsylvania
Stanley P. Rockwell Company
Hartford 12, Connecticut
C. U. Scott & Son, Inc.
(Stainless Steels)
Rock Island, Illinois
Standard Steel Treating Co.
Detroit 10, Michigan
Syracuse Heat Treating Corp.
Syracuse, New York
Winton Heat Treating Company
Cleveland 16, Ohio

This advertisement sponsored by these Companies which are members of the Metal Treating Institute.

METAL TREATING INSTITUTE 271 NORTH AVENUE NEW ROCHELLE, NEW YORK

TITANIUM STRIP is descaled continuously on time cycles as low as 30 seconds, with excellent results.

10-MINUTE IMMERSION loosens scale on 5 tons of stainless wire. A water quench, 3-minute acid dip, and final water rinse produce a clean, bright surface with no pitting or etching.



LIGHT-GAUGE ALLOY STRIP is descaled at 20-35 ft. per min. in this Virgo bath, after annealing.

Use this fast, safe Hooker Process for descaling steel and titanium

Descale alloy steels and titanium in any form—rapidly, safely—using the Hooker Process with Virgo® Descaling Salt.

A bath of molten Virgo Descaling Salt quickly converts scale, rust, and other surface impurities to an acid-soluble coating. A quench, acid dip, and final spraying then remove this coating in from one-tenth to one-hundredth the usual pickling time, with no measurable effect on the base metal.

You can easily set up the Hooker Process for batch or continuous operation on any form of work including strip, sheets, bars, wire, tubes, plate, castings, forgings, and fabricated parts. You can usually process work as fast as your handling methods allow, with a minimum of supervision. Operation is safe for personnel, and there is little or no spent-acid disposal problem.

You can profit by the experience of more than 50 companies now using the Hooker Process successfully to speed up descaling of alloy steels and titanium in practically every form.

You'll get quick service on any descaling problem, by writing or phoning us. Complete test and engineering facilities are at your disposal, without obligation.

Send for these bulletins—Get the whole story on Virgo Descaling Salt for alloy steels and titanium . . . how the Hooker Process works, its advantages, how to set up a Virgo descaling line, and the services you enjoy as a user. No obligation. Write us today.

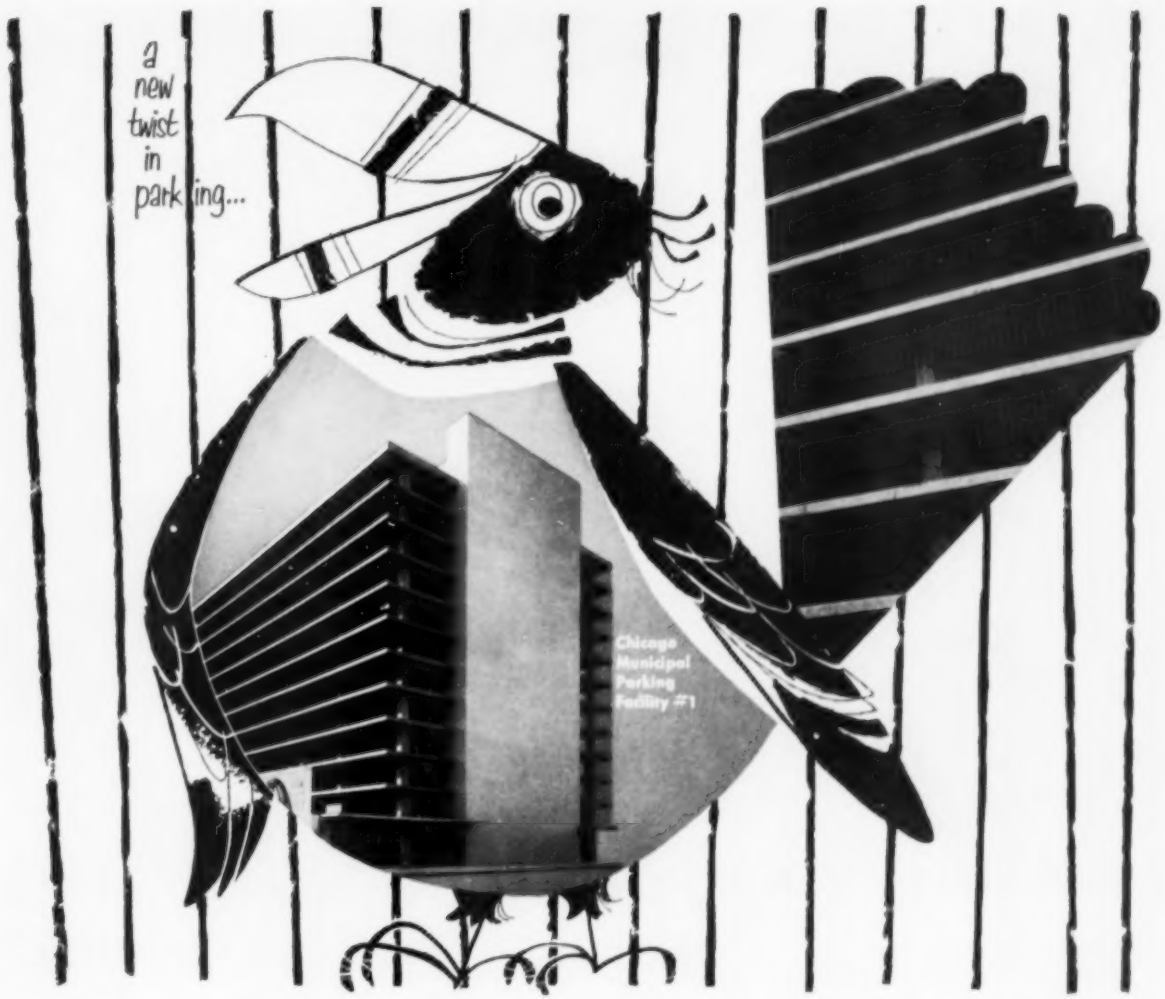
From the Salt of the Earth

HOOKER ELECTROCHEMICAL COMPANY

30 Forty-seventh St., Niagara Falls, N. Y.

NIAGARA FALLS • TACOMA • MONTAGUE, MICH. • NEW YORK • CHICAGO • LOS ANGELES

HOOKER CHEMICALS



12 STORY "BIRD CAGE" SEALED IN SAFETY WITH **STAINLESS STEEL STRAND!**

Want more proof of stainless steel's versatility? Here it is: this time as a protective cable barrier in the "Bird Cage" garage – Chicago's new twist in solving parking problems.

The ⅜ in. stainless steel strand is strong enough to withstand the impact of a car traveling 40 mph! The cable assembly does away with old methods of masonry and solid wall construction, too. And what a difference that makes in construction costs!

No wonder more and more architects and designers are looking to stainless steel. It can solve both structural and decorative requirements in a single member. For economy and practicality, no other metal can match it.

Put stainless' beauty, strength and corrosion resistance to work for you, too. Your supplier has full particulars on how it can be engineered profitably in your product.

a new twist in design... The sweep and flow of modern auto design is made possible through the beauty of stainless steel—corrosion resistance makes it ideal for interior and exterior decorative parts.

Our 50 Years of Progress

The finest stainless steels are made with Vancoram ferro alloys.

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Producers of alloys, metals and chemicals

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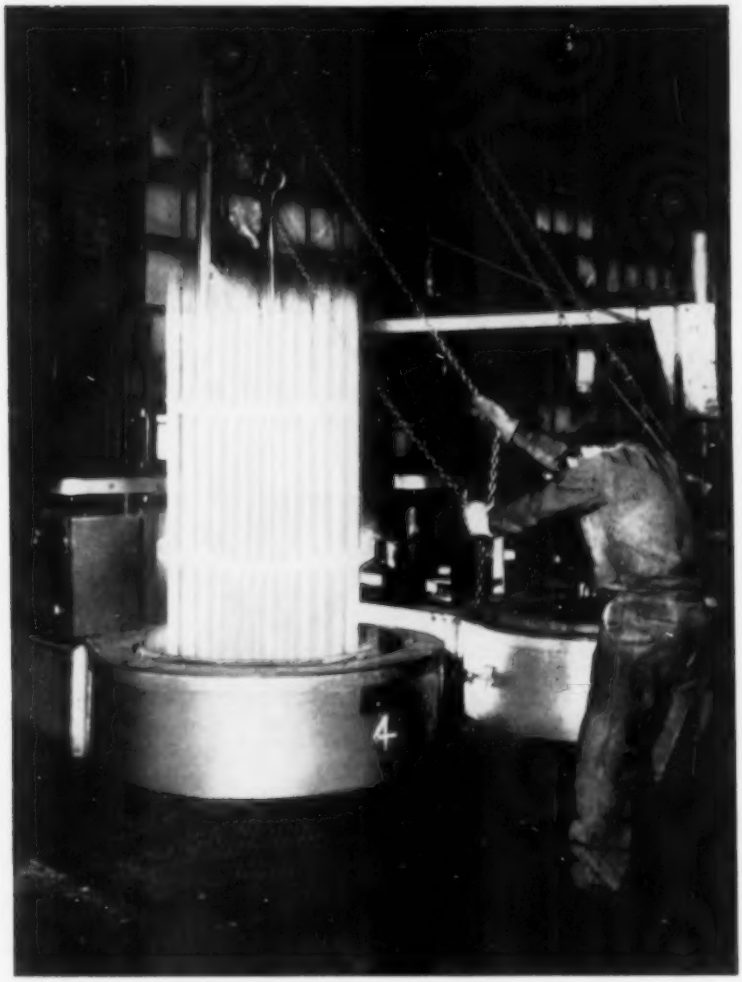


Controlled Quenching

WILL BRING OUT THIS CHARGE UNIFORM IN QUALITY

The quenching stage of your heat-treating process is the point where all previous operations are brought to either a successful or unsatisfactory conclusion.

At this point is determined the final quality of your product...the amount of time and material wasted by sub-standard rejects ...and *your ultimate operating cost!*

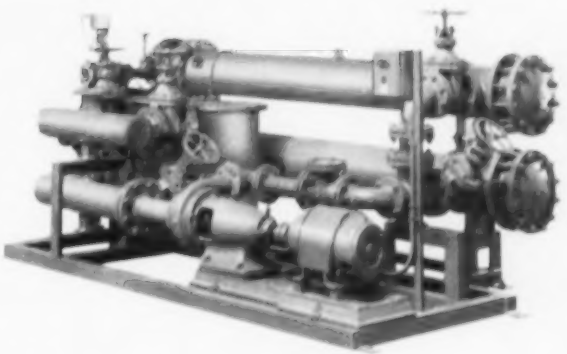
When you install a B & G *Hydro-Flo* Oil Quenching System you eliminate the warping and quality variations caused by uncontrolled quenching of heat-treated metal.

Oil is circulated at high velocity and with strong turbulence through the quench tank—then cooled and pumped back again. The oil in the quench bath is kept constantly at whatever temperature is desired. Since every batch is quenched under *identical conditions*, every batch is *identical in quality*.

While the individual components of an oil cooling installation can be purchased and assembled on the job, the trend today is to install completely factory-assembled oil cooling systems.

To meet this demand, B & G offers completely self-contained oil cooling units—integrated in every respect—ready for immediate operation. These units are engineered to your specific requirements.

Whether your heat treating volume is large or small, the services of the B & G engineering department are available. Your request for information will receive prompt attention.



The B & G Self-Contained Oil Cooler illustrated here is pre-engineered and assembled complete at the factory. It eliminates the need for building pump piers and stands and for assembling pipe, valves, controls and wiring. Your only responsibility is to place the unit in position and connect it to the quench tank and water lines. It can be easily moved if a change in plant arrangement makes it necessary.

Hydro-Flo® OIL QUENCHING SYSTEMS

BELL & GOSSETT COMPANY

Dept. EG-16. Morton Grove, Ill.

Canadian Licensee: S. A. Armstrong, Ltd., 1400 O'Connor Drive, Toronto

*Reg. U. S. Pat. Off.

102 Hands

To Help You Find the Answers to Descaling Problems

Du Pont customer service men—located throughout the country—have a wealth of experience at their finger tips to help you with any descaling problem.

Only a phone call away when needed, these service men are completely familiar with all phases of Sodium Hydride Descaling—a process pioneered by Du Pont. If you are descaling any metal unaffected by fused caustic at 700°F., it would be to your advantage to talk to one of them about this modern descaling process.

There's no cost for this service—which includes laboratory investigation of problems, plus expert aid in construction, installation and operation of the process. A call to the nearest Du Pont district office will bring you complete information.

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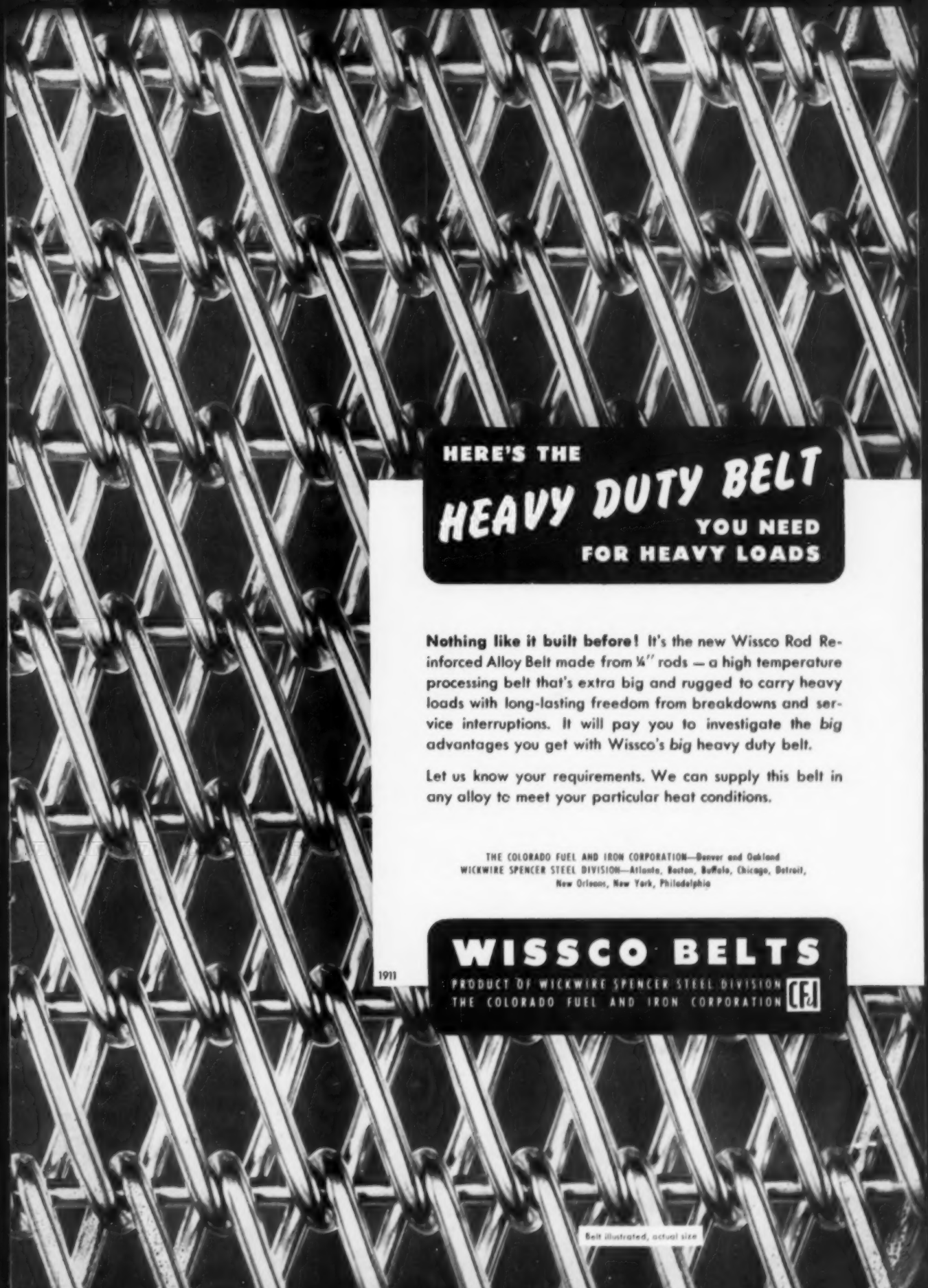

HERE'S THE

HEAVY DUTY BELT

YOU NEED FOR HEAVY LOADS

Nothing like it built before! It's the new Wissco Rod Reinforced Alloy Belt made from ¼" rods — a high temperature processing belt that's extra big and rugged to carry heavy loads with long-lasting freedom from breakdowns and service interruptions. It will pay you to investigate the *big* advantages you get with Wissco's *big* heavy duty belt.

Let us know your requirements. We can supply this belt in any alloy to meet your particular heat conditions.

THE COLORADO FUEL AND IRON CORPORATION—Denver and Oakland
WICKWIRE SPENCER STEEL DIVISION—Atlanta, Boston, Buffalo, Chicago, Detroit, New Orleans, New York, Philadelphia

1911

WISSCO BELTS

PRODUCT OF WICKWIRE SPENCER STEEL DIVISION
THE COLORADO FUEL AND IRON CORPORATION CF&I

Belt illustrated, actual size

Inspection with Magnaglo and black light reveals a crack in this axle.

How MAGNAGLO* Helps Cut Costs

—and Insures Reliable Quality at Clark Equipment Company

Finding crack-type defects in parts during production helps to keep costs down, and insure safety and dependability. These are prime aims at Clark Equipment Company. They know these aims can best be realized by methods that produce consistent reliable quality, economically.

To be sure of this, they utilize Magnaglo inspection. It is faster than visual—and much more accurate. Magnaglo helps find any possible cracks and helps determine the cause.

They save money by using inspection with Magnaglo to eliminate much waste motion. Time is not spent in completing cracked parts, since defects are discovered in the rough stage. Machining and labor costs are thus reduced, to keep Clark's costs and prices low and very competitive.

The $2500 Magnaglo unit was originally purchased as an aid to inspection in the axle shaft department. The inspection has now proven of value on many other parts, including knuckles, arms, and drive axles. Good sampling inspection practices usually serve to control quality in transmission and steering parts, bushings, tie-rod ends and bolts, and find "bugs" in manufacture before they cost money.

Quite likely one of the many Magnaflux Corporation test methods can do the same for you. Various methods work on every type material, at any stage of manufacture. Kits and units sell from $35.00 up to a few thousand dollars. No license required. Ask to have a Magnaflux* engineer call—or write for our bulletin on LOWER PRODUCTION COSTS.

Magnaflux and Magnaglo are Registered Trademarks of Magnaflux Corporation

MAGNAFLUX CORPORATION
7346 West Lawrence Avenue
Chicago 31, Illinois

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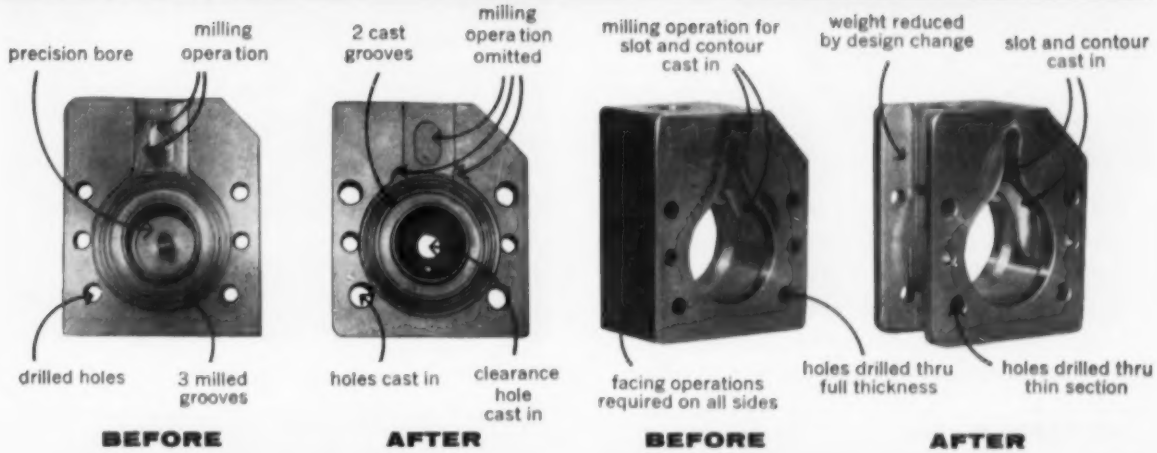
MAGNAFLUX

Proof of the pudding—a Clark fork truck operator deposits a skid of axles at the Magnaflux inspection station. Axles of this truck were originally inspected here.

For the past ten years, Clark Equipment Company has been using a Magnaflux unit similar to this model DR-543, with Magnaglo and hood. Other models at low price are available to suit your requirements.

In casting pump parts
AKH* *makes the difference*

*** Advanced Know-How**



Machining time on the stainless steel housing for the Vanton "flex-i-liner" pump was cut from 14 hours down to 2 through the use of shell cores; weight was reduced and drilling simplified through casting redesign; and the use of shellcast eliminated the milling on the end plates, making it economical to produce them in stainless steel instead of aluminum. This resulted in a better product in less time and for less money thanks to Cooper Alloy *Advanced* Know-How.

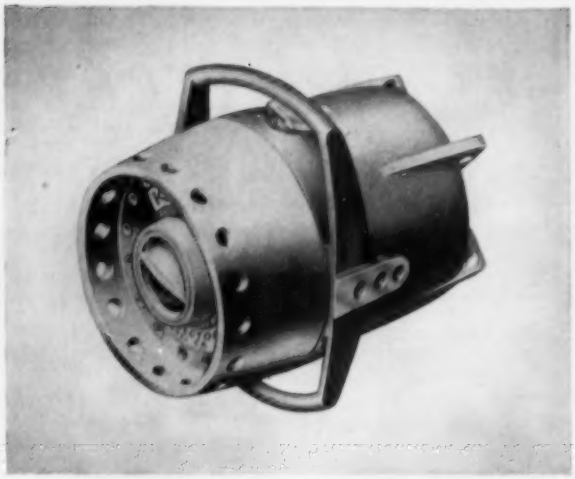
For full details on this specific application write for free copy of case study #2.

COOPER ALLOY
CORPORATION • HILLSIDE, N.J.

Foundry Products Division

The KEL-RAY Projector

a portable tool for low-cost radiography



Here is a new development employing radioactive cobalt, iridium, or cesium as a source of gamma rays. One of the most practical means yet devised for industrial non-destructive testing, the KEL-RAY Projector lowers costs and simplifies procedures wherever radiographic testing can be applied. Here's why:

PORTABLE—Requiring no external power, the KEL-RAY Projector is available in three portable sizes, the smallest of which can be moved by hand.

SAFE—Ruggedly constructed, equipped with tamper-proof shutter, it is designed and built to keep radiation leakage at a minimum—well below AEC and ICC safety requirements.

ECONOMICAL—Initial and operating costs are low. Requires no maintenance during life of isotope. Set-up time and man-power are minimized.

EASY TO USE—Simple to operate on light or heavy material up to 8 inches thick by anyone properly trained.

For information on how the KEL-RAY Projector can meet your needs, write for Bulletin P196P.

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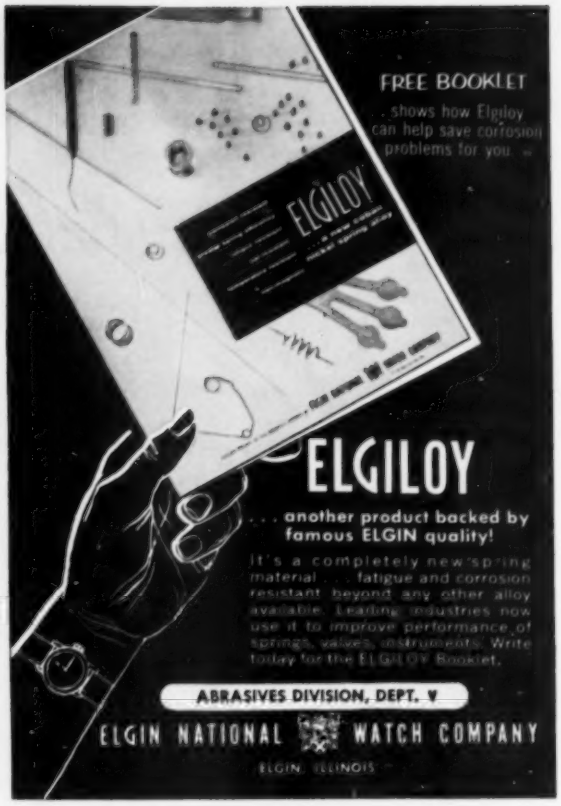


The Materamic 38 Taximeter
Manufactured by
THE VIKING TOOL & MACHINE CORP.
2 MAIN STREET • BELLEVILLE, N.J.

"THE BERYLLIUM COPPER CASTINGS IN THIS TAXIMETER WILL OUTLAST THE TAXI!"

The gears and cams used in this taximeter bear against steel pins and shafts. Steel castings won't hold up—as steel wears on steel, shafts are worn, holes elongated, and tolerances expanded to the point that the meter operates erratically.

In four of the most critical, high-friction wear points, cast "BERYLCO" brand beryllium copper parts are now providing these necessary advantages:

Machining costs are obviated—in castings, beryllium copper yields an end product consistent with original mold design, achieving tolerances of .0005".

The delicate lobes, ratchets, cams and teeth that characterize the four cast parts could only be molded by beryllium copper —no other alloy would hold such fine detail.

The parts are susceptible to rust and corrosion . . . an ever-present problem with steel which has been eliminated altogether by using beryllium copper alloys.

A Rockwell of C-37 to C-43 is achieved by a simple heat treatment. The part is first solution annealed at 1475°F. for 3 hours and water quenched immediately . . . then heat treated at 600°F. for 2 hours and air cooled. The expansion of the part during heat treatment is controlled to within .002", far less than with comparable materials. Expensive machining costs are prevented, since the part is pin-pointed to the design specifications in the original cast.

There has never been a failure of any beryllium copper part in the taximeter, even though these meters are used in the nation's toughest proving ground—the New York City taxi service. On the testing rack, each meter is run for 2000 miles at 120 mph and 25% overvoltage, plus 700 miles under regular conditions. Part wear and clearances are exactingly checked, and it is here that these cast "BERYLCO" brand beryllium copper parts have demonstrated that they will outwear and outlast the service life of any taxi on the road.

A technical bulletin (#32) discussing in detail the use of "BERYLCO" brand beryllium copper castings as they are used in this taximeter is available upon request. This bulletin is instructive reading, and we recommend that it be made a part of your permanent files. Write to:

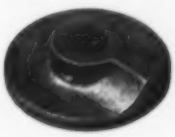
THE BERYLLIUM CORPORATION

BERYLCO

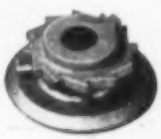
DEPT. 6C, READING 9, PENNSYLVANIA

"BERYLCO" Brand Beryllium Copper is Shelf-Stocked by Leading Warehouse Distributors.
Export Department, Reading, Pennsylvania • Cable Address "BERYLCO"

FLAG INDEXING CAM; one of the most complicated single-cast parts ever produced . . . it has lobes, teeth, ratchets, cams, a square tapered hole, and a disengaging stop. Steel could never be cast in such a complication of design, and brass is too soft to take the beating. The tapered socket measures .628" with a tolerance of —0.005" and +0.00".

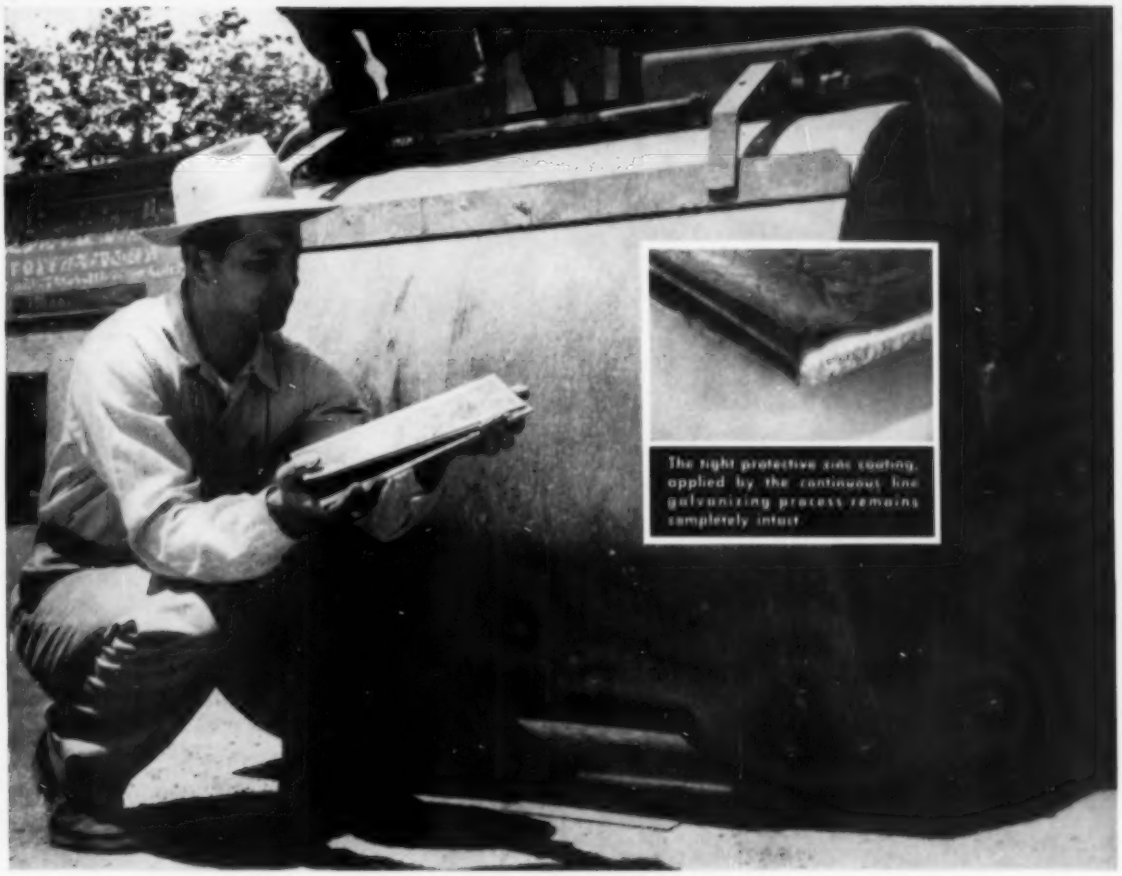


BRAKE ACTUATING CAM; a zinc alloy formerly used for this part would not stand up under the terrific amount of wear imposed . . . it would change size as much as 1/16", break, and come off the shaft. The zinc alloy was replaced by a beryllium copper casting, which, with simple heat treatment, registers a Rockwell of C-37 to C-43, more than enough to withstand the rigors of operational stress.

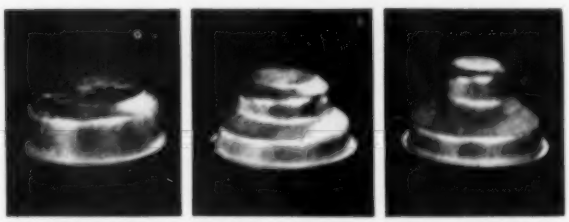


RATCHET HUB; used to operate the "extras" tabulation, which is actuated by a lever binding against the ratchet periphery of this part. The center hole of this part must fit over a steel stud in what amounts to a lap fit with a minimum acceptable tolerance of .001". It was impossible to maintain this tolerance with steel, and machining costs were out of proportion. The part is now cast of "BERYLCO" brand beryllium copper to specifications which require a hub of .250" with tolerances of —0.00" and +.002".

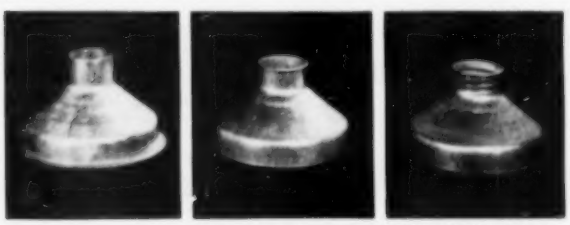
RETURN LEVER CAM; has an outside diameter of 1.565", pitch of 16, contains 23 teeth with a circular pitch of .1963". The depth of the teeth is .1348", and the thickness of the teeth .098". Used to reset the dollar and cents scale, this cam is under very high spring tension at all times, and nothing but the most hardened material could withstand this duty.



THE SHAPE OF THINGS TO COME



AN EXAMPLE: This sprinkling can rosette was formerly made of black plate and then electroplated to provide the necessary rust-proofing; it is now produced from flat, galvanized stock in six operations without chipping, cracking, peeling or flaking of the protective zinc coating.



Photos of rosette, courtesy WHEELING STEEL CORP.

The progress that has been made in the United States to take full advantage of the unexcelled qualities of zinc as a protective metal is dramatically illustrated here. Many products made of galvanized sheet steel are pressed into shape by terrific force. But if a galvanized sheet can be flattened into a *double fold* under the crushing weight of a road roller without failure of the protective zinc coating, it is obvious that it will withstand equally well the severest drawing and forming operation.

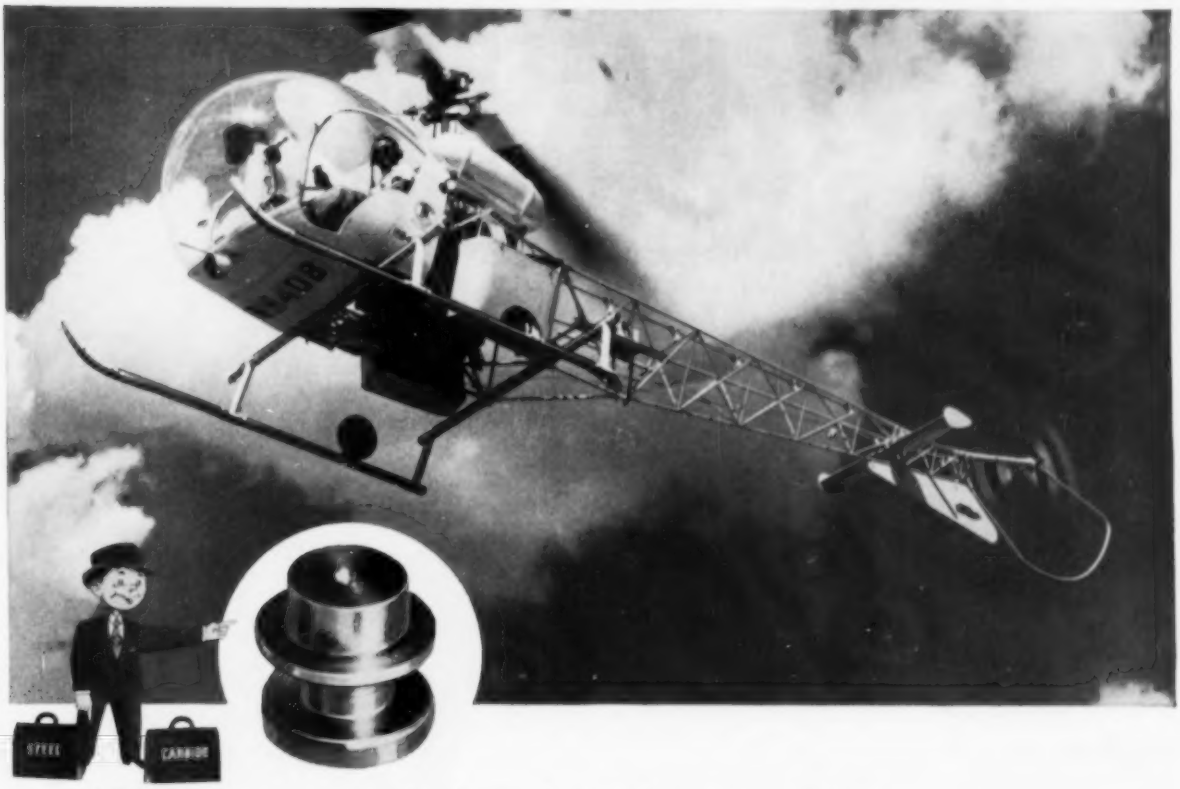
The improved properties of today's continuous line products has led to an enormous increase in their consumption. The zinc coating being as ductile as the base metal, anything that can be made of steel sheets, can now be made of galvanized sheet.

ST. JOSEPH LEAD COMPANY
250 PARK AVENUE, NEW YORK 17, N. Y.

HIGH GRADE
INTERMEDIATE
PRIME WESTERN

ST. JOE *electrothermic* ZINC

"Mission accomplished" at Bell Aircraft...with FIRTHITE TXH



133% more needle bearing pins per grind

Down Fort Worth way at famous Bell Aircraft Corporation, they made production tests on the *new* FIRTHITE TXH Carbide . . . turning and facing needle bearing pins from SAE 4140 steel.

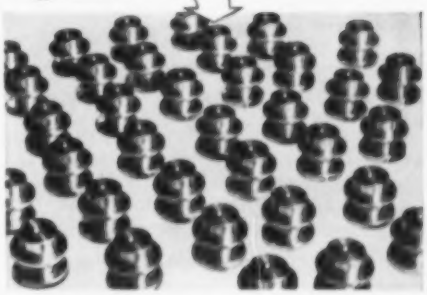
The results speak for themselves:

- 133% more bearing pins per grind.
- More than twice as many pieces per grind as nearest premium grade.
- Seven times more pieces per grind than two other competitive grades.
- Only .007 stock removed to resharpen compared with .025—.035 for competitive grades.

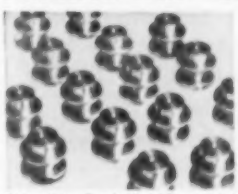
Truly this test proves, as do others all over the country, that FIRTHITE TXH is easily the outstanding carbide in its field . . . a *premium grade* at *no* premium price.

Yes, FIRTHITE TXH is a completely *new* carbide concept . . . a combination of materials and processes designed specifically to do heavy-duty, high-production cutting operations better than they have ever been done before!

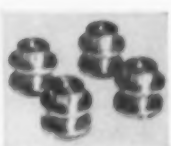
You, too, can make important savings, and increase production with TXH. It's available *now* in all standard tips and tools. Try it today.



FIRTHITE TXH—35 PER GRIND



Competitive Grade A—15 per grind



Competitive Grades B & C—4-5 per grind

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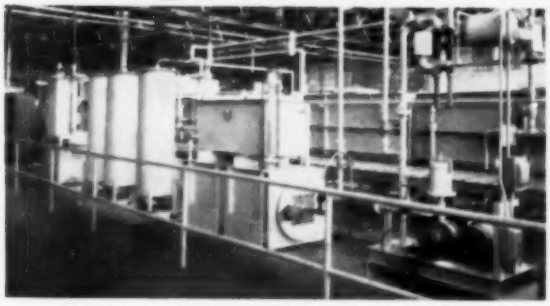
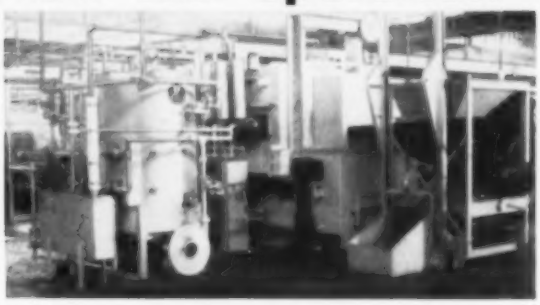
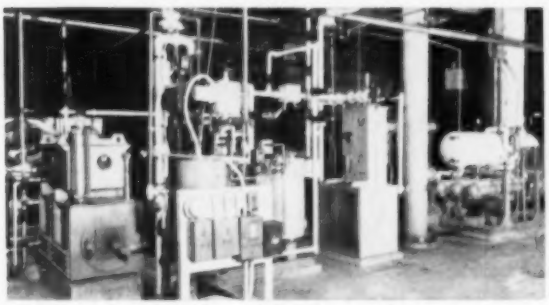


A lean ratio EF exothermic gas generator, with desulphurizers and refrigerator, produces the special atmospheres for the EF continuous bright annealing furnace shown in background. This is one of several EF units in a large copper and brass wire mill.

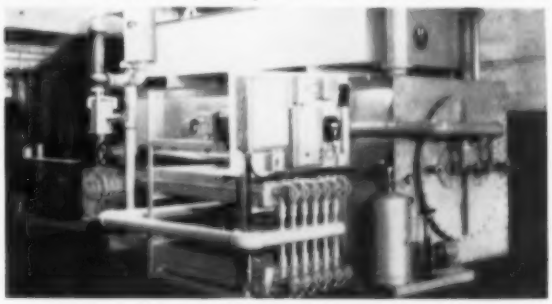


This EF special atmosphere generator has special adapter to enable it to operate either as an exothermic or endothermic generator. It is used in connection with the continuous EF bolt hardening furnace at right, for scale free hardening or for carbon restoration.

SPECIAL ATMOSPHERE EQUIPMENT

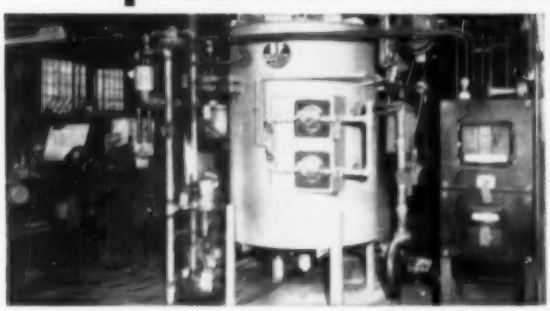


EF special dry, high nitrogen atmosphere equipment consisting of an exothermic generator, a CO_2 removal unit, a refrigerator type dehydrator, and a dryer for producing a dry, high nitrogen gas with low H_2 content suitable for bright annealing miscellaneous steel and non-ferrous products in various forms.

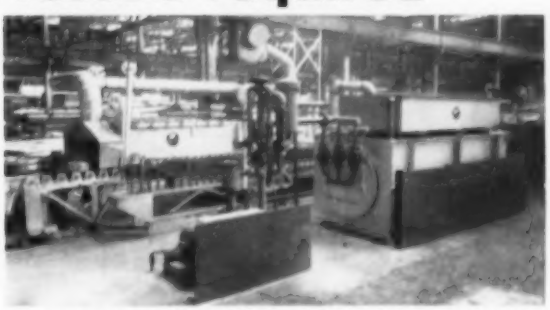


EF kerosene exothermic generators are available in various sizes and types for areas where gaseous fuels are not obtainable. This 12,000 cfh kerosene unit is shown undergoing our regular factory tests, prior to shipment to South America for use with EF furnaces for bright annealing copper and scale-free annealing brass.

produces the exact results required



This 3000 cfh endothermic type atmosphere generator is heated by natural gas. It produces atmospheres for scale-free and non-decarb hardening miscellaneous small and medium size parts continuously, in an EF gas fired radiant tube chain belt conveyor furnace.



This EF 12,000 cfh lean ratio exothermic horizontal water cooled type generator provides the special atmosphere for the EF gas fired continuous furnace shown in the background. This installation is used for bright annealing copper tubing both in coils and straight lengths.

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Years of practical experience in designing and building special atmosphere furnaces and generators enable EF engineers to furnish rugged, efficient, heat processing equipment with a reputation for successful, low cost operation and maintenance.

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